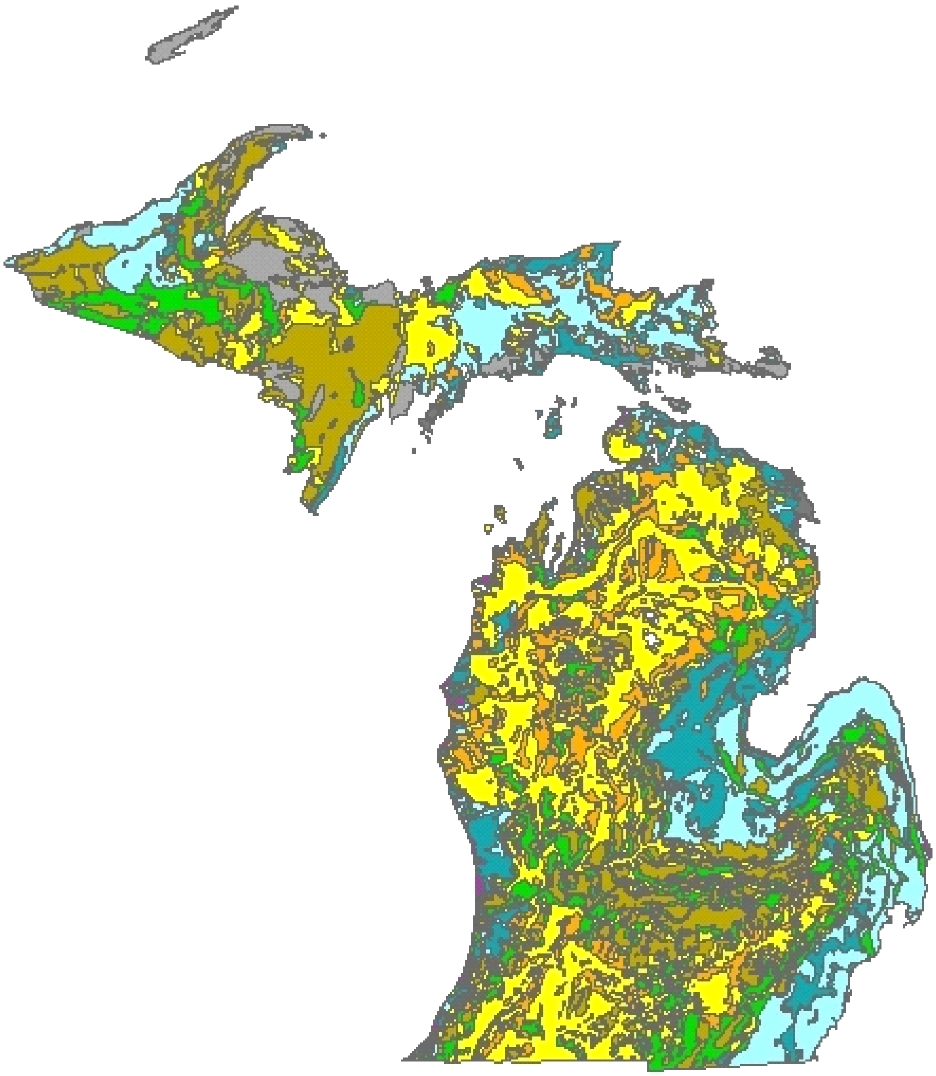
Final Report to the Michigan Legislature
in response to Public Act 148 of 2003



Groundwater Conservation Advisory Council
February 6, 2006

Cover Figure. Glacial landsystems in Michigan. *Source: MDEQ Groundwater Inventory and Map*

CONTENTS

This report is available on the Internet at
www.deq.state.mi.us/documents/deq-gwcac-legislature.pdf

INTRODUCTION

Without doubt Michigan is as water-rich as any place on earth. Often called the "Water Wonderland" because of its 3,251 miles of Great Lakes coastline and more than 35,000 mapped lakes and ponds, Michigan includes parts of four Great Lakes. The Great Lakes contain 5,080 cubic miles of water and contain about 20 percent of all of the fresh surface water on earth. Michigan averages about 32 inches of precipitation each year, amounting to 86 billion gallons per day. Over 36,350 miles of streams connect Michigan's land to the Great Lakes.

Groundwater is one of Michigan's most important natural resources. It provides about 23 percent of public water supply. In addition, more than 2.7 million people, including most of the rural population, supply their own water from domestic wells. Groundwater is also a significant source of water for industry and irrigation. As a result, groundwater is an important source of water in every county in Michigan.

Furthermore, groundwater is a major contributor to streams, inland lakes and wetlands, and Great Lakes coastal wetlands. It has a strong influence on aquatic habitats for plants and animals. Michigan's coldwater fisheries, among the finest in the nation, are dependent upon groundwater flow to streams and lakes.

The pumpage of fresh groundwater in Michigan in 2000 was estimated to be about 730 million gallons per day (MGD), which is about 2.6 percent of the estimated 27 billion gallons per day of natural recharge to Michigan's groundwater systems. From a statewide perspective, the groundwater resource appears ample. Locally, however, the availability of groundwater varies widely. Moreover, only a part of the groundwater stored in the subsurface can be recovered by wells in an economic manner and without adverse consequences.

Groundwater sustainability means different things to different people. Defining groundwater sustainability, on one hand, requires scientific understanding of the groundwater system and its relation to the rest of the hydrologic system and to aquatic ecosystems. On the other hand, it requires societal decisions regarding the acceptability of the effects of groundwater development on groundwater levels, surface water, and aquatic ecosystems. A significant benefit of efforts to define groundwater sustainability is that doing so fosters a long-term perspective regarding future needs and the state of the environment.

In recent years, groundwater sustainability has become an issue in Michigan, principally because of conflicts between owners of large-capacity wells and owners of small-capacity domestic wells. Additionally, questions have been raised regarding the effects of groundwater withdrawals on levels and flows in streams, inland lakes and wetlands, and the Great Lakes. To begin addressing groundwater sustainability, Michigan passed legislation in 2003 to address groundwater conflicts, to inventory and map Michigan's groundwater resources, and to create the Groundwater Conservation Advisory Council.

In August 2003, Public Act 148 became law. Section 32803, states:

> *(1)The groundwater conservation advisory council is created within the department. The council shall consist of the following members:*
>
> *(a) Three individuals appointed by the senate majority leader representing business and manufacturing interests, utilities, and conservation organizations.*
>
> *(b) Three individuals appointed by the speaker of the house of representatives representing well drilling contractors, local units of government, and agricultural interests.*

(c) Four individuals appointed by the director representing nonagricultural irrigators, the aggregate industry, environmental organizations, and the general public.

(d) Three individuals representing the department, the department of agriculture, and the department of natural resources, as nonvoting members who shall serve as information resources to the council.

(2) The council shall do all of the following:

(a) Study the sustainability of the state's groundwater use and whether the state should provide additional oversight of groundwater withdrawals.

(b) Monitor Annex 2001 implementation efforts and make recommendations on Michigan's statutory conformance with Annex 2001, including whether groundwater withdrawals should be subject to best management practices or certification requirements and whether groundwater withdrawals impact water-dependent natural features.

(c) Study the implementation of and the results from the groundwater dispute resolution program created in Part 317.

(3) Within 2-1/2 years after the effective date of the amendatory act that added this section, the council shall submit a report, approved by the majority of the voting members of the council, on its findings and recommendations under subsection (2) to the senate majority leader, the speaker of the house of representatives, and the standing committees of the legislature with jurisdiction primarily related to natural resources and the environment.

(4) Effective 6 months after the council submits its findings and recommendations under subsection (3), the council is disbanded.

Purpose and Scope

The purpose of this report is to address the topics set forth by the Michigan Legislature in 2003 PA 148, Section 32803, Subsection (2). The scope of the report includes background information on groundwater and groundwater development in Michigan, legislation and regulatory framework, and findings and recommendations resulting from Council deliberations.

Acknowledgments

The Council thanks the agencies, companies, and organizations that supported Council activities by generously providing for salary and travel costs associated with Council work: Prein & Newhof, Consumers Energy Company, Annis Water Resources Institute—Grand Valley State University, Wayne County Department of Environment, Mersino Dewatering Inc., Michigan Environmental Council, Tri-County Regional Planning Commission, Michigan Aggregates Association, Michiana Irrigation Association, and The Rock on Drummond Island. The Council also thanks Laura Smith, MDEQ, and Cindy Brewbaker, MSU Institute of Water Research, for assisting with the logistics of Council activities and meetings.

The Council thanks invited guests who made presentations on various topics critical to Council deliberations, including Ron Van Til, Mike Gaber, Joe Lovato, Elgar Brown, Howard Reeves, Dave Lusch, Steve Miller, Jim Olsen, Michael Haines, and Scott Slater. The Council also benefitted from and appreciated the participation of guests representing the Michigan Farm Bureau and Trout Unlimited. The Council also acknowledges the participation of former MDA appointee Vicki Pontz.

The Council acknowledges the technical assistance of the U.S. Geological Survey's Michigan Water Science Center at Council meetings and in the preparation of this report, in particular Center Director Jim Nicholas. USGS support was funded through a cooperative agreement composed of MDEQ and USGS Cooperative Water Program funds. In addition, Jim Bredin, MDEQ Office of Great Lakes participated in Council meetings to provide insight into progress on the Annex 2001 Implementation Agreements.

Finally, the Council relied heavily on a number of publications in writing this report. While not cited within the main body of the report, these publications are referenced in Appendix A.

FRAMEWORK, FINDINGS AND RECOMMENDATIONS

This is the report of the Groundwater Conservation Advisory Council, as required by 2003 PA 148. The Council members represent a broad spectrum of viewpoints and concerns with respect to groundwater use in Michigan. Clearly, members of the Council are not in agreement with every aspect of Michigan's groundwater use issues. The Council did agree, however, to report on a consensus basis. That is, the information in this report, including all findings and recommendations, are agreed upon by all voting members. Prior to completion of this report, the Council decided upon a set of guiding principles, agreeable to all members, that form the foundation for perspectives and viewpoints represented in this report. These guiding principles follow.

Guiding Principles

1. Michigan has an abundance of water resources, both groundwater and surface water. Certain groundwater sources can support a large amount of withdrawal without harm to other users or to the ecosystem. Other groundwater sources are more vulnerable to large withdrawals.
2. There is no overall shortage of water in the State. Currently, groundwater withdrawals in Michigan do not present a crisis.
3. Groundwater sustainability involves balancing the demands placed on the resource by the economic, social, and environmental sectors, ensuring that the needs of current and future generations are not compromised by current usage. The resource should be managed for current and future use based on well-founded scientific analysis.
4. The Council recognizes that conservation of our groundwater and our surface water includes both the efficient use of water and also the protection of quality.
5. Groundwater is a valuable asset, and if used efficiently, can provide the basis of a strong economy and high quality of life in Michigan. Nearly half of Michigan's population relies on groundwater for drinking water. Many others rely on groundwater for a variety of other purposes.
6. The Council has studied groundwater and withdrawals of water from groundwater sources, not surface water. However, the Council recognizes that groundwater and surface water are strongly interrelated and cannot be viewed as separate and distinct.
7. Michigan does not have a coordinated statewide process to manage groundwater use; such a process could minimize water-use conflicts and adverse environmental impacts.

Recently a groundwater dispute resolution statute was enacted to supplement Michigan common law for evaluating reasonable use.

8. Some areas of the state have been identified as sensitive to groundwater withdrawal. Current and future withdrawals in these areas require a higher degree of monitoring, scientific research, and understanding.
9. Not all groundwater withdrawals are alike, and have differing levels and types of impacts; how much water that would be withdrawn, from where (location and depth), at what frequency and time of year, and ecological conditions are all major factors that determine whether and where an impact may occur.
10. Additional monitoring of stream flows, groundwater levels, aquatic ecosystems, and related mapping and analysis is essential to protecting groundwater resources.
11. Consistency and predictability of regulation between state and local units of government are essential to managing the resource. The state should encourage regional and multi-jurisdictional approaches to groundwater management and wellhead protection.
12. Local, voluntary, problem-solving approaches for resolving groundwater disputes and withdrawal impacts are the desirable starting point for conflict resolution.
13. The Council has not prioritized water use by type of user or by purpose of use. We recognize that the amount of groundwater withdrawn from an aquifer must be sustainable.

Meaning of Conservation

The Council discussed at length the concept and meaning of "conservation", in particular, whether or not "conservation" implies using less water. In Council discussions and in this report, "conservation" does not necessarily imply using less water. Rather, the use of the word "conservation" by the Council embodies the concepts of stewardship, sustainability, and efficiency of use. The Council agreed to define "conservation" as follows:

> *Conservation means that to meet the needs of existing and future users and to ensure that habitats and ecosystems are protected, the use of the State's water must be done in a sustainable and renewable manner. Sound water-resource management emphasizes careful and informed use of water, which is essential to meet these objectives.*

Council Meetings

The Council agreed at its first meeting that all meetings would be open to the general public, and the Council benefitted from dialogue with non-member participants. Although the Council originally planned to meet quarterly, they soon agreed to more frequent meetings, nearly monthly for the past year, resulting in 17 meetings of the full Council. Meetings were held in various locations throughout Michigan. Additionally, the Council set up three subcommittees that met to discuss and bring recommendations to the full Council on the topics of Sustainability, Annex 2001, and the Groundwater Dispute Resolution Program. Council members spent about 120 hours each attending full Council meetings; a considerable amount of additional time was spent in subcommittee meetings, reading and evaluating Council materials, and on conference calls. Travel was also considerable, more than 10,000 miles for one of the Council members. Meeting agendas, minutes, and other information regarding the Council can be found at: http://www.michigan.gov/deq/0,1607,7-135-3313-86262--,00.html

Council Membership

As set forth by 2003 PA 148 there are 10 voting members of the Council appointed by the State Legislature and the Director of Michigan Department of Environmental Quality (MDEQ). Additionally, 3 nonvoting members represent MDEQ, Michigan Department of Agriculture (MDA), and Michigan Department of Natural Resources (MDNR). At its second meeting, the Council agreed to be led by 3 co-chairs. Council membership is as follows:

Jon Allan (co-chair)
Consumers Energy Company
Appointed by Senate Majority Leader
Representing Utilities

Kurt Heise (co-chair)
Wayne County Dept of Environment
Appointed by Speaker of The House
Representing Local Units of Government

Jim Cleland (co-chair) (non-voting)
Appointed by Director, Dept of Environmental Quality
Representing Michigan Department of Environmental Quality

Thomas Newhof
Prein and Newhof
Appointed by Senate Majority Leader
Representing Business and Manufacturing Interests

Alan Steinman
Annis Water Resources Institute—Grand Valley State University
Appointed by Senate Majority Leader
Representing Conservation Organizations

Fred Henningsen
District Agriculture and Irrigation Agent Emeritus, Michigan State University
Appointed by Speaker of The House
Representing Agricultural Irrigators

Rod Mersino
Mersino Dewatering, Inc.
Appointed by Speaker of The House
Representing Well Drilling Contractors

James Clift
Michigan Environmental Council
Appointed by Director, Dept of Environmental Quality
Representing Environmental Organizations

Jon Coleman
Tri-County Regional Planning Commission
Appointed by Director, Dept of Environmental Quality
Representing General Public

Michael Newman
Michigan Aggregates Association
Appointed by Director, Dept of Environmental Quality
Representing Aggregate Industry

Craig Hoffman
The Rock on Drummond Island
Appointed by Director, Dept of Environmental Quality
Representing Nonagricultural Irrigators

Paul Seelbach (non-voting)
Appointed by Director, Dept of Natural Resources
Representing Michigan Department of Natural Resources

Michael Gregg (non-voting)
Appointed by Director, Dept of Agriculture
Representing Michigan Department of Agriculture

Findings and Recommendations following from 2003 PA 148, Sec. 32803(2)

2003 PA 148, Section 32803(2) requires the Groundwater Conservation Advisory Council to address specific issues. This section is organized according to the issues contained in this legislation and addresses these issues with a series of findings and recommendations.

Study the sustainability of the state's groundwater use and whether the state should provide additional oversight of groundwater withdrawals

Finding 1—Sustainability means different things to different people and adoption of a definition promotes informed debate.

Recommendation 1—Michigan should adopt a modified version of the Brundtland Commission's definition of sustainable development: *Sustainable use of Michigan's groundwater resources means (1) meeting the needs of the present while not compromising the ability of future generations to meet their needs and (2) recognizing that sustainable use encompasses environmental, economic, and social systems and their contribution to meeting human needs*.

Finding 2—Criteria and indicators are useful tools in evaluating sustainability.

Recommendation 2—Michigan should develop a set of criteria and indicators to evaluate the sustainability of Michigan's groundwater use and conduct this evaluation on an ongoing basis. Development of criteria and indicators should be a broad and open process, including subject-matter experts in environmental, economic, and social systems.

Finding 3—The status of Michigan's groundwater resources relevant to selected indicators has not been determined, nor are there ongoing efforts to track changes.

Recommendation 3—Michigan should develop and implement a program to determine the current status of selected indicators and to measure and track future changes.

Finding 4—Groundwater levels in Michigan move up and down in response to natural factors and human activities. The amount of water-level change varies from aquifer to aquifer and from one area of the state to another. No statewide groundwater-level monitoring network exists to track changes and to ascertain whether changes are caused by natural factors or by human activities. Furthermore, 2003 PA 177, Sec. 31703(1)(d) states "That the lowering of the groundwater level exceeds normal seasonal water level fluctuations...." Without monitoring of water levels in areas unaffected by pumping, normal seasonal fluctuations cannot be accurately determined.

Recommendation 4—Michigan should develop and implement a plan for a statewide groundwater-level monitoring network. The plan should incorporate and leverage on-going monitoring, take into account the former statewide network, and specify which monitoring is a state need and which is a local need. The state should fund state needs and provide matching or start-up funds for local needs. The current cooperative statewide streamflow monitoring network is an excellent model of leveraging state and local funding to produce a robust statewide network, at minimal cost to all parties.

Finding 5—The effects of groundwater withdrawals from glacial aquifers on nearby wells and aquatic ecosystems often are difficult to understand or to reliably predict without an understanding of the texture, thickness, and extent of glacial deposits in three dimensions. This understanding is needed for a number of other important reasons, including groundwater supply, contaminant movement, and mineral-resource supply.

Recommendation 5—Michigan should prioritize and fund basic 3-dimensional geologic mapping of glacial deposits. Prioritization should consider areas of the state where current or future groundwater withdrawals have the potential to affect small-capacity wells or aquatic ecosystems.

Finding 6—Michigan's Water Use Reporting Program is now one of the best in the Great Lakes Region. The program provides required information to meet state laws and Great Lakes Charter agreements. The program can provide useful indicators of sustainability, if strengthened and supported.

Recommendation 6—Michigan should provide for ongoing funding and staffing of the Water Use Reporting Program. Full reporting should be encouraged from all use sectors that are included in the Program.

Monitor Annex 2001 implementation efforts and make recommendations on Michigan's statutory conformance with Annex 2001, including whether groundwater withdrawals should be subject to best management practices or certification requirements and whether groundwater withdrawals impact water-dependent natural resources

Finding 7—While Michigan law is in general conformance with some aspects of the final Annex Implementing Agreements signed December 13, 2005, there are many provisions with which Michigan law does not conform. These areas are shown in table 5.

Recommendation 7—Passage of new legislation that is very similar to legislation being considered by the Michigan Legislature in January 2006 would significantly move Michigan forward toward statutory conformance with Annex 2001.

Finding 8—Michigan does not have a coordinated statewide process to manage groundwater use; such a process could minimize water-use conflicts and adverse environmental impacts.

Recommendation 8—Michigan should build upon existing programs to develop a coordinated statewide process to manage groundwater use to prevent adverse impacts to natural resources and to assess the potential for impacts on other water uses.

Finding 9—A comprehensive law review article does not currently exist on groundwater and groundwater rights in Michigan.

Recommendation 9—A comprehensive review and summary of Michigan law related to groundwater and groundwater rights should be conducted, outside of legal briefs related to any single case and outside the scope of Council activities.

Finding 10—Michigan's Generally Accepted Agricultural Management Practices (GAAMP) for irrigation and the Turfgrass Environmental Stewardship Program provide good models of water-use sectors developing sector-specific water-management practices. Farms and golf courses have the opportunity to voluntarily self-certify that they have implemented the water-management practices specific to their sector.

Recommendation 10—Each water-use sector should develop its own sector-specific water-management practice. These should be reviewed and evaluated by a closely related professional or trade association. Water users within each sector should be encouraged to adopt and implement the water-management practices specific to their sector.

Finding 11—Determining the effects of specific groundwater withdrawals on specific biota in aquatic ecosystems is extremely difficult. Available research and data, however, indicate that development of statewide assessment tools is currently possible.

Recommendation 11—Develop a statewide assessment tool that identifies surface water and aquatic ecosystems potentially at risk to large individual or cumulative groundwater withdrawals. Construction of the tool should account for and use, among other things, the considerations and products described in this report under "Groundwater development and use in Michigan", in particular the section on "Effects on aquatic ecosystems".

Finding 12—Although considerable research has been conducted relating groundwater and fisheries, similar research relating groundwater to other species in aquatic ecosystems, such as freshwater mussels, invertebrates and plants, has not been conducted.

Recommendation 12A—Michigan should prioritize and fund basic and applied research that examines the dependence of Michigan's aquatic ecosystems on groundwater flow to surface water. Prioritization should consider at-risk species and areas of current or future large groundwater withdrawals.

Recommendation 12B—Michigan should implement a long-term, statistically-designed, statewide status-and-trends field inventory program for aquatic ecosystems. This inventory should include a range of aquatic animals and plants, and must be strongly linked to groundwater, hydrologic setting and geomorphic setting. MDNR Fisheries Division has such a program started for fish in streams and lakes, and the new MDNR *Comprehensive Wildlife Management Strategy* calls for such a comprehensive inventory. This inventory data set, sampling across space and through time, will provide the basis for improved modeling of patterns and relationships of attributes of Michigan's streams, wetlands, and lakes.

Recommendation 12C—Michigan should conduct large-scale experiments where groundwater is withdrawn from different aquifer types and from aquifers connected to different aquatic ecosystems. These experiments will help to establish cause and effect relationships between groundwater withdrawals and potential individual and cumulative impacts on aquatic ecosystems.

Study the implementation of and the results from the groundwater dispute resolution program created in Part 317.

Finding 13—A predevelopment water budget, particularly an estimation of natural recharge, is of limited value in determining the amount of groundwater that can be withdrawn on a sustained basis. However, 2003 PA 177, Sec. 31703(2) links conflicts and sustainability to the amount of recharge to an aquifer, stating "...that continued groundwater withdrawals from a high-capacity well will *exceed the recharge capability of the groundwater resource of* the area...." This situation, where withdrawals exceed recharge, has not arisen in Michigan to date.

Recommendation 13—The quoted language in 2003 PA 177 should be modified to allow for conflicts when withdrawals do not exceed recharge, for example, "...that continued groundwater withdrawals from a high-capacity well will *adversely impact low-capacity wells in* the area...."

Note—See also Appendix B, which is the report on the groundwater dispute resolution program delivered by the Council to the Legislature on June 20, 2005.

Findings and Recommendations following from 2003 PA 148, Sec. 32802 (Groundwater Inventory and Mapping)

Concurrent with the work of the Council, MDEQ was conducting a groundwater inventory and mapping project (GWIM), as directed by 2003 PA 148, Sec. 32802. This project was completed by a multi-agency team comprised of MDEQ, USGS, and MSU. Upon conclusion of the project in August 2005, the Council asked the team for findings and recommendations that might follow from their project. Upon consideration of the team's response to this request, the Council has the following findings and recommendations relevant to 2003 PA 148. These are not directly requested under Sec. 32803, but in the Council's judgement are related to the issues raised in that section.

Finding 1—GWIM is an excellent tool, useful to the private sector, the public, researchers and government agencies. If not maintained and enhanced, its value will gradually diminish and a significant investment of State resources will be lost.

Recommendation 1A—Michigan should provide for the maintenance and enhancement of the maps and data compiled in GWIM. Needed maintenance and enhancements are summarized below, based upon the GWIM project team's final report.

Database maintenance and enhancement

- Continue to add relevant scientific reports to GWIM.
- Continue to maintain Wellogic (MDEQ's computerized well log database), adding new well records in a timely fashion.
- Enter data from the scanned historic well records (about 800,000 are available) into Wellogic, prioritizing areas where electronic well records are scarce.
- Continue to provide outreach and technology transfer on the use and importance of Wellogic.
- Pursue consistency in water-use reporting requirements. Current inconsistencies include reporting either capacity or use, reporting use by facility or well, and reporting use aggregated by township.
- Develop a process to streamline the mapping of water use and provide tools to MDEQ and MDA to simplify the mapping procedure as new data are submitted each year.

Mapping maintenance and enhancement

- Explore ways to obtain hydraulic characteristics of aquifers, especially in data-poor areas, with a priority on areas of potential future water-resource development.

•Update the improved bedrock topography map and the improved thickness map of the glacial deposits that were created by this project. Much of the information required for this updating task was collected and scanned during the GWIM project.
•Develop large-scale, local, 3-D maps identifying the major confined and unconfined aquifer zones in the glacial deposits. Such a task was considerably beyond the scope of work of the GWIM project team.
•Support and expand the detailed glacial geology mapping of the Michigan Office of Geological Survey with a focus on relating this effort to groundwater-resource management.

Additional data and information needs

•Study and report on the temporal trends in the existing groundwater-level data. This analysis would provide insight to areas of Michigan that are more or less sensitive to drought, and provide a water-use and climatological context to the reported water levels.
•Expand streamflow monitoring network to improve estimates of baseflow and recharge.
•Collect low-flow streamflow measurements for currently ungaged watersheds to confirm the baseflow estimates and provide additional data to improve these estimates.
•Research and develop practical methods to link aquifer analyses, water-use information, and baseflow and recharge estimates to evaluate the ecological impact of future groundwater resource development.

Recommendation 1B—Michigan should invest the necessary resources to maintain and enhance GWIM.

GROUNDWATER IN MICHIGAN

Groundwater occurs everywhere beneath the land surface in Michigan. Groundwater occurs in pore spaces between particles of rock in glacial deposits and bedrock or in networks of fractures or solution openings in bedrock. Groundwater is constantly moving (figure 1). Under natural

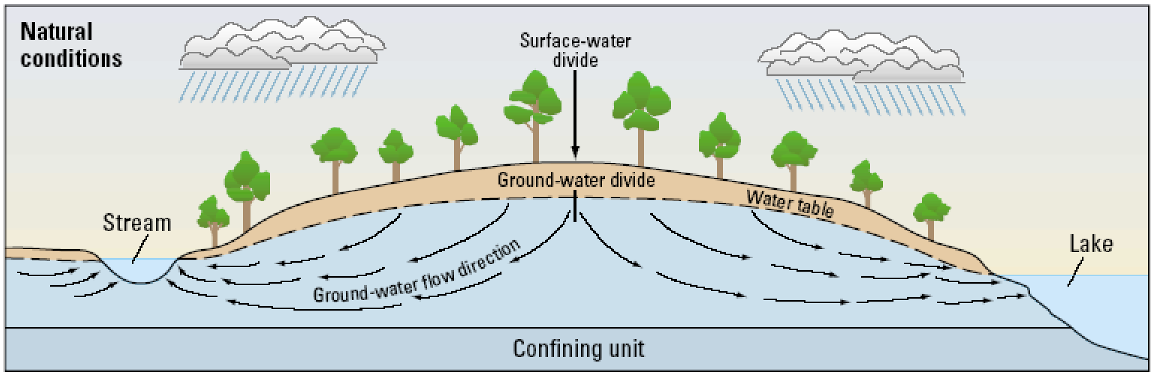


Figure 1. Groundwater is constantly moving, usually from upland areas to discharge into surface-water bodies. Although not shown in this diagram, many surface-water bodies have places where surface water moves downward into the groundwater.
Source: USGS Water Resources Investigations Report 00-4008

conditions, groundwater moves along flow paths from areas of recharge to discharge in surface-water bodies. The rate of movement is related to the amount of recharge, the ability of the geologic materials to transmit water (quantified as hydraulic conductivity), and the size and interconnectedness of pores or other openings in rock (quantified as porosity). The rate of groundwater movement is much smaller than that of streams—a foot per day is a high velocity for groundwater and a foot per year or decade is not an uncommon velocity for groundwater in some areas of Michigan. Consequently, the age of groundwater (time since recharge) may range from less than a day to tens of thousands of years (figure 2).

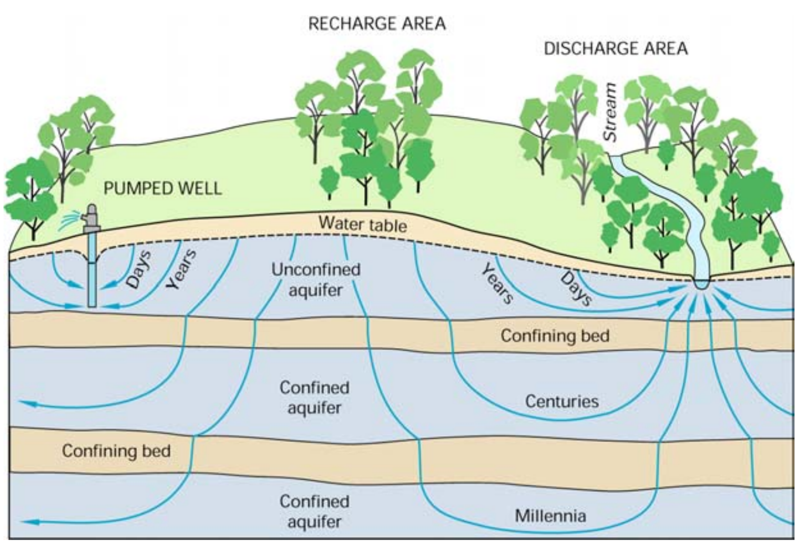


Figure 2. Travel times of groundwater from the water table to discharge in surface-water bodies and wells are highly variable. The deeper the flow path and the more confining units that groundwater moves through, the longer the travel time.
Source: USGS Circular 1139

Aquifers are geologic materials that yield sufficient quantities of water for the intended use. Aquifers may be composed of hard, solid material such as sandstone or limestone, or of loose unconsolidated material, such as sand or gravel. Confining units restrict the movement of water. Typically confining units are composed of fine-grained material, such as shale or clay.

Hydrogeology

Aquifers and confining units in Michigan can be characterized as bedrock and glacial. From a statewide perspective, bedrock aquifers generally are better understood than are glacial aquifers. The primary reason for this is that bedrock aquifers are usually of widespread extent and often have relatively consistent properties throughout their extent. Additionally, a large amount of hydraulic data from municipal wells in bedrock aquifers are compiled by and available from MDEQ. In contrast, glacial aquifers are more limited in their extent and the hydraulic properties of the deposits may be highly variable in three dimensions. Although hydraulic data from many municipal wells completed in glacial aquifers are compiled by MDEQ, these data are typically unique to the particular local flow systems from which they derive. Where glacial deposits overlie bedrock, which occurs throughout most of Michigan, groundwater flow systems in the glacial deposits and bedrock are interconnected.

Bedrock aquifers

Most of Michigan is within the geologic structure called the Michigan Basin (figure 3). This structure can be conceptualized as a set of bowls nested one within another. Typically fresh

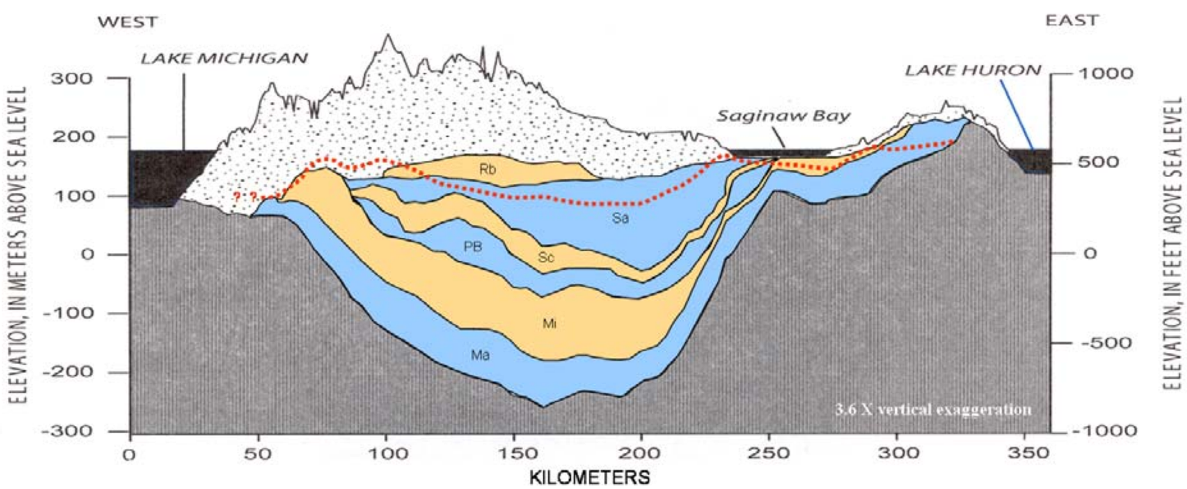


Figure 3. A generalized section across the middle of the Michigan Basin. Glacial material is at the top (stippled area); the blue units are bedrock aquifers; the brown units are bedrock confining units; and the gray area at the bottom is the Coldwater Shale, a confining unit that is the base of the Michigan Basin regional aquifer system. The dotted red line defines the bottom of fresh potable water.
Source: Michigan Groundwater Inventory and Map, based on USGS Professional Paper 1418

groundwater can be obtained near the rims of the bowls, whereas brackish or saline water occurs deeper into the bowls. In the western Upper Peninsula, other bedrock aquifers occur that are not part of the Michigan Basin (figure 4).

The principal bedrock aquifers in Michigan's Lower Peninsula are the Marshall, Saginaw, and Carbonate aquifers. Flow in these aquifers is generally from recharge areas where a bedrock aquifer directly underlies glacial deposits toward the center of the Michigan Basin and then out of the basin to Lake Huron and Lake Erie. Some of these recharge areas are outside of Michigan. For instance, a principal source of water to the Carbonate aquifer in southeastern Michigan is in northern Indiana.

The hydraulic properties of the Marshall and Saginaw aquifers have been quantified reasonably well in areas where they yield fresh water, and they are somewhat consistent from place to place. The hydraulic properties of the Carbonate aquifer have also been quantified reasonably well in areas where they yield fresh water. The hydraulic properties of the Carbonate aquifer, however, are extremely variable from place to place, primarily because groundwater in this aquifer moves through solutional openings that range greatly in width and interconnectedness.

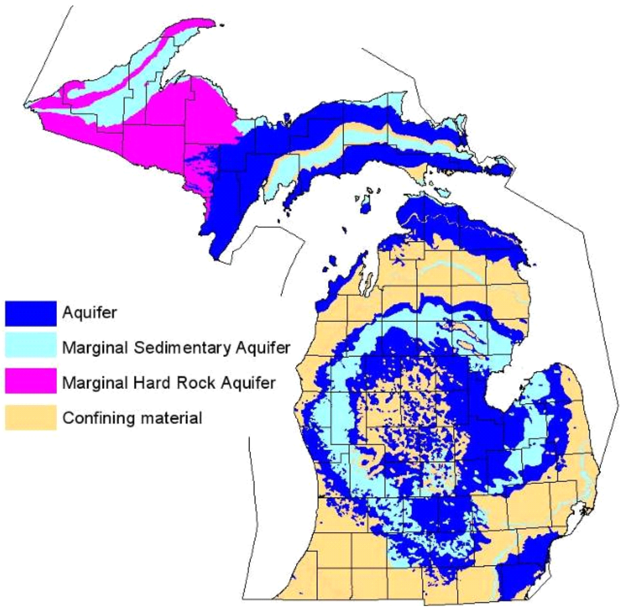


Figure 4. Distribution of bedrock aquifers and confining units in Michigan.
Source: Michigan Groundwater Inventory and Map

In Michigan's eastern Upper Peninsula, the aquifers are the Carbonate aquifer in the south and sandstone aquifers in the north. Groundwater in the Carbonate aquifer generally flows south toward Lakes Michigan and Huron. Groundwater in the sandstone aquifers flows to the south also, however, in some areas it flows north to Lake Superior. In the western Upper Peninsula, aquifers primarily are composed of crystalline metamorphic and volcanic rocks.

In contrast to the Lower Peninsula, hydraulic properties for bedrock aquifers in the Upper Peninsula have been poorly quantified. What is known is that hydraulic properties for most of the Upper Peninsula are similar to those in the Carbonate aquifer of the Lower Peninsula. That is, the hydraulic properties are highly variable from place to place, because usually they are controlled by fractures and solution openings. In some areas of the western Upper Peninsula, wells drilled into bedrock will not yield usable quantities of water.

Glacial aquifers

In this report, the term glacial aquifers includes all aquifers composed of unconsolidated geologic materials, whether or not these materials were deposited by glaciers, streams, lakes, or wind. Glacial deposits cover almost the entire land surface of Michigan. Some of these deposits are composed primarily of sand or larger grains through which groundwater moves with ease, and these are aquifers. Other deposits are composed mostly of small grains, such as silt or clay, through which groundwater movement is restricted, and these are confining units.

Mapping glacial aquifers requires a knowledge of the thickness, extent, and texture (grain size) of various glacial deposits. In general, these deposits resulted from the complex movement of water beneath or at the margins of glaciers. After initial deposition, many deposits were reworked by subsequent glacial events, streams, wind, or a combination of these. Consequently, maps of surficial glacial geology cannot be relied upon to map glacial aquifers beneath the land surface. Glacial aquifers can only be mapped on the basis of geologic information from wells or geophysical methods. Even thin layers of clay within an otherwise sandy deposit can have a

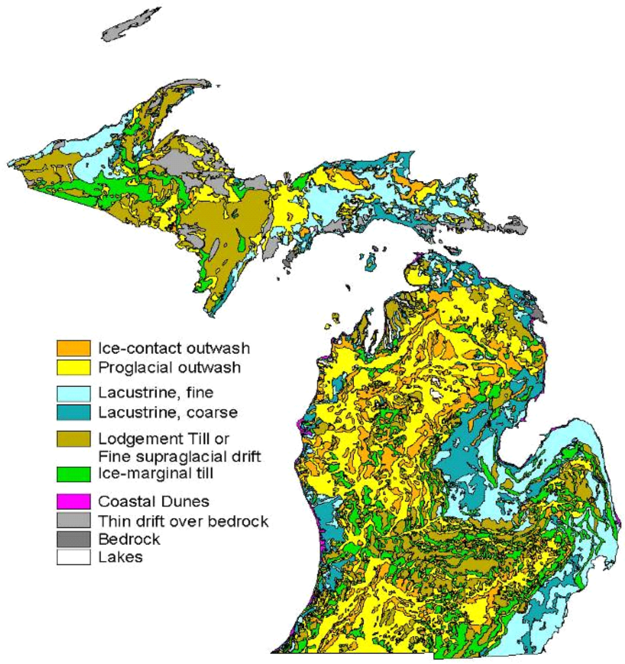


Figure 5. The type and texture of glacial materials at the land surface is very complex, despite the simplification needed to make a statewide map. The distribution of glacial materials below the land surface is equally complex, however, no statewide subsurface maps exist.
Source: Groundwater Inventory and Map

profound effect on the direction and rate of groundwater flow.

Glacial deposits in Michigan range in thickness from zero, in areas where they have been eroded or removed, to more than 1200 feet in Wexford County. From a statewide perspective, the thickness of glacial deposits is generally well known. Records from water, oil, gas, and brine wells note the top of the bedrock surface throughout much of the state. Thickness of glacial deposits can then be calculated by subtracting the altitude of the bedrock surface from the altitude of the land surface.

The extent and texture of glacial deposits at the land surface are generally well known from a statewide perspective (figure 5), although the most recent statewide map is known to have errors in places. Beneath the land surface, however, the extent and texture of glacial deposits are generally poorly known from a statewide perspective (figure 6). Although hundreds of thousands of drilling logs record the geologic materials

Figure 6. Detailed subsurface mapping of glacial deposits in Berrien County illustrates the difficulty of determine subsurface texture from surface maps. The “X” on the map above includes subsurface textures ranging from very course poorly sorted cobbles, gravel and sand (upper right) to well-sorted fine sand (right). The groundwater flow rate through these materials may differ by a factor of 10,000 or more.
Source: MDEQ Office of Geological Survey

encountered while installing water wells, they are usually too general to allow a geologist to unravel the depositional history of the glacial materials, a necessary part of estimating the extent of glacial aquifers.

The movement of groundwater is controlled mostly by the hydraulic conductivity of the geologic materials, which is a function mostly of the texture of the materials. In glacial deposits, hydraulic conductivity may range over many orders of magnitude—from 0.0000001 feet per day in clay to more than 10,000 feet per day in gravel. Consequently it is critical to know the extent, texture, and thickness of glacial deposits to understand and quantify the groundwater flow system.

Groundwater movement in glacial aquifers in Michigan can be generalized, despite the complexities of the glacial deposits. The uppermost surface of the groundwater—the water table—typically is similar in shape and elevation to the land surface. That is, the water table is highest in upland areas between streams. Therefore groundwater generally moves from these uplands toward streams or other surface-water bodies in low areas. Much of the groundwater discharges to nearby streams. Some groundwater, however, moves deeper and discharges to larger streams or the Great Lakes outside of the subwatershed within which it is recharged. Some groundwater also moves deeper and recharges bedrock aquifers.

Relation of Groundwater to Surface Water

Nearly all groundwater in Michigan naturally discharges to surface water. Some groundwater travels only a few feet and only a few days before it discharges to a stream, inland lake, wetland, or Great Lake. Other groundwater travels tens or hundreds of miles and for years, centuries, or millennia before it discharges to surface water. Groundwater is a significant part of the flow to most of Michigan's surface-water bodies.

The groundwater component of streamflow (baseflow) in Michigan is large and has been estimated using long-term records of streamflow (figure 7). On average, about 80 percent of the

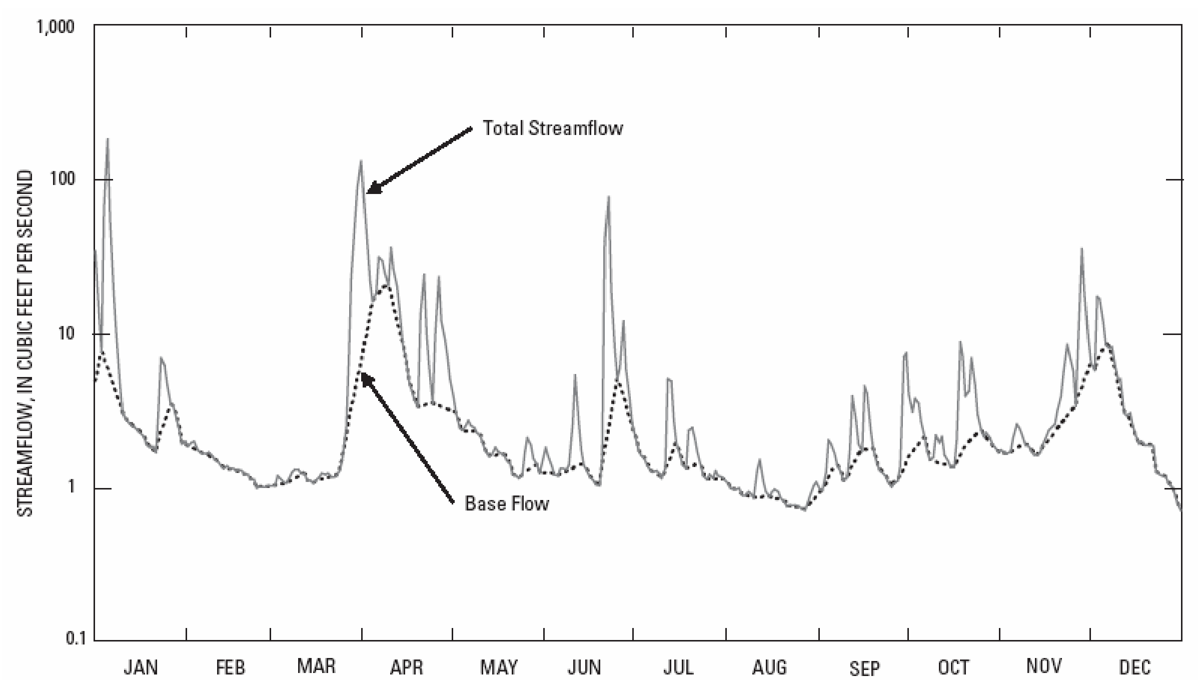


Figure 7. Baseflow in streams is a large part of the total streamflow for many of Michigan's streams. Like total streamflow, baseflow is variable throughout the year, generally being lowest in late summer and winter, and being highest during times of high streamflow.
Source: USGS Scientific Investigations Report 2005-5217

annual streamflow in the Lower Peninsula results from groundwater discharge (figure 8). Under natural conditions, groundwater is a small component of streamflow only in limited areas of Michigan where geologic deposits with low hydraulic conductivity occur at or very near the land surface.

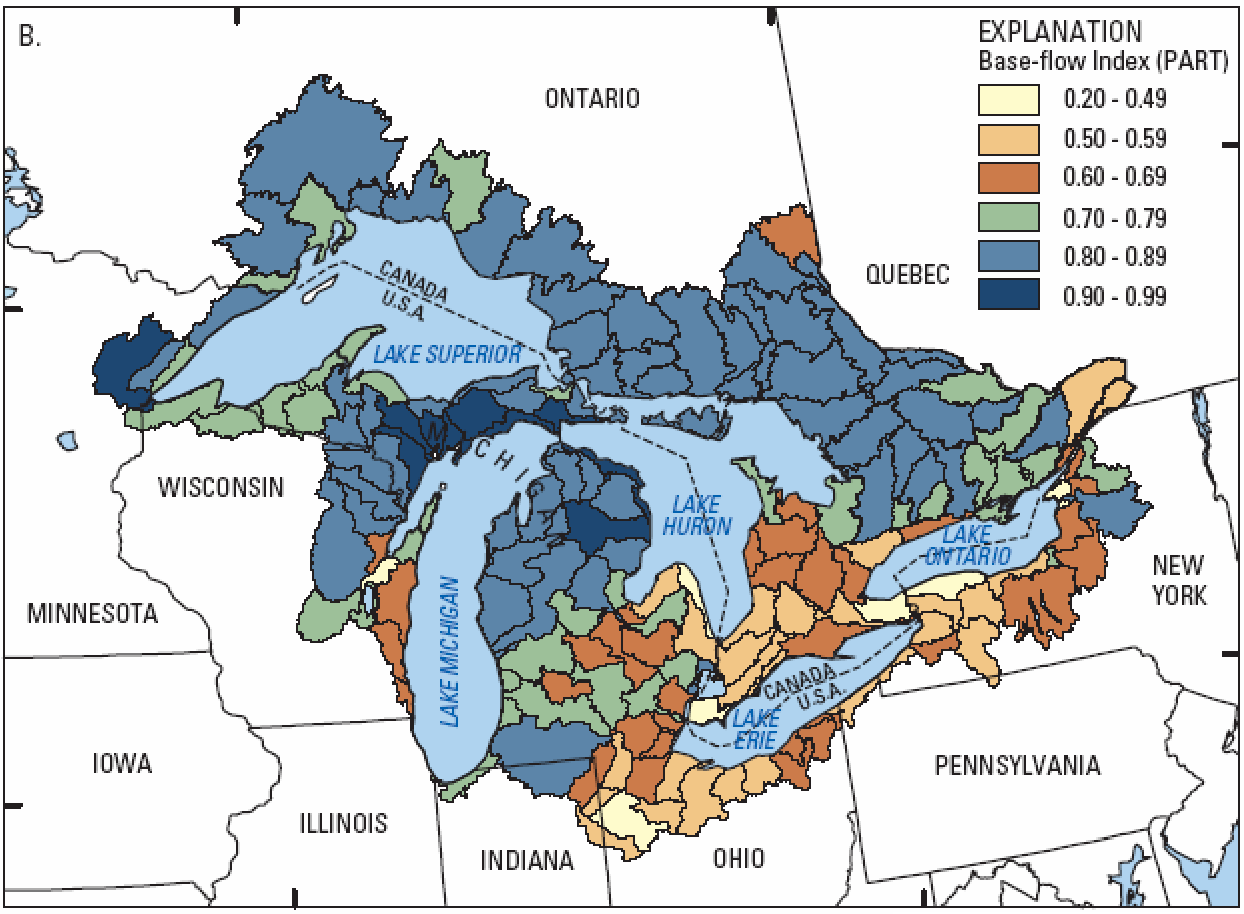


Figure 8. Baseflow is a large percentage of the total annual streamflow in Michigan. Baseflow index (BFI) can be read as the percent of total annual streamflow that is baseflow. Thus a BFI of 0.79 means that 79 percent of the total annual streamflow is baseflow.
Source: USGS Scientific Investigations Report 2005-5217

Groundwater is a significant part of the water budget for most inland lakes and wetlands in Michigan. Many lakes and wetlands do not have streams flowing into them, and groundwater, therefore, is the only inflow besides precipitation on the surface of the lake or wetland. Groundwater flow into lakes and wetlands is complex and generally requires detailed study to understand. Groundwater may flow into some areas of lakes and wetlands; in other areas, water may flow from the lake or wetland into the groundwater system. Additionally, the location and rates of flow often change seasonally. Therefore, statewide or watershed-wide estimates of groundwater flow to inland lakes and wetlands are difficult to make with currently available data and information.

The Great Lakes are the discharge area for regional groundwater flow systems in Michigan, as well as for local flow systems near the Great Lakes. Little is known regarding the amount and rate of groundwater discharge into the Great Lakes, although USGS estimates direct groundwater discharge to Lake Michigan to be about 5 percent of the total water input. Nearshore wetlands, however, have been studied at several locations throughout the Great Lakes. These studies have all shown that the existence and longevity of nearshore wetlands depend upon groundwater. During periods of low water levels on the Great Lakes, wetlands develop in the nearshore due to groundwater discharge (figure 9).

Figure 9. During low water levels on the Great Lakes, wetlands may form due to groundwater discharge between the lake and the bluff, such as this one at Little Point Sable, Michigan. *Source: Bonnie P. Nicholas*

Relation of Groundwater to Aquatic Ecosystems

Most aquatic ecosystems in Michigan are dependent upon the discharge of groundwater into surface water (groundwater inflow). The role of groundwater in providing the cool summer water temperatures that sustain trout is well understood, and considerable research has been conducted in Michigan on the linkages between groundwater discharge, stream temperature, and fish species distributions. Similar linkages to other stream-dwelling animals and plants are less understood. High groundwater discharge likewise is associated with certain wetland types, such as fens and cedar swamps. Such linkages to inland lake ecosystems are not well understood.

Stream ecosystems can be understood as being shaped and constrained by hydrologic pattern, or flow regime, coupled with geomorphic setting. A stream's flow regime is determined by the amount and temporal distribution of precipitation, the amount of evapotranspiration, and the routing of waters to the stream, either quickly overland or more slowly through aquifers. A stream's geomorphic setting is determined by the slope and texture of the tributary watershed and the form of the stream's channel. Stream hydrology ranges from those dominated by groundwater inflow, such as the famed Au Sable and Manistee rivers, to those dominated by runoff over the land surface, such as those that form the Saginaw River.

Habitats and biota develop in response to each stream's particular flow regime. Higher flows are channel forming—by eroding and depositing sediment and woody debris, high flows create the basic shape of a stream's flood plain and channel. Some stream biota are adapted to the high flow patterns, taking advantage of these flows for reproduction or feeding. Low flows fill the channel's bottom during periods of little or no rainfall or snowmelt, and streams with high groundwater inflow maintain colder, swifter, and deeper conditions. Summer is the primary season of reproduction and growth for stream animals and plants, and species are adapted for life in specific low-flow, or baseflow, habitats. Trouts require cold, swift, rocky summer habitats, while sunfishes and catfishes prefer warm, slow, and silty habitats.

The relative contribution of groundwater to stream baseflow varies widely across Michigan, and its pattern is reflected in the distribution of aquatic animals and plants (figure 10). In areas of

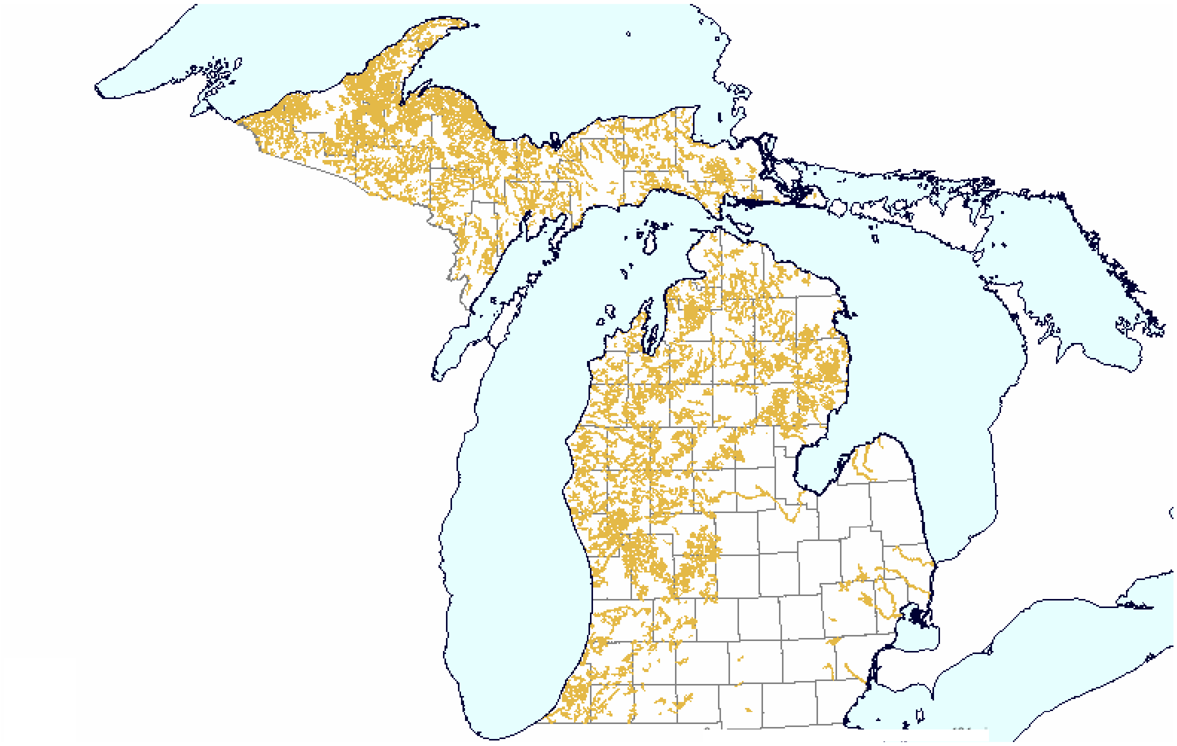


Figure 10. Location of trout streams in Michigan.
Source: Michigan Groundwater Inventory and Map, based on Michigan Natural Features Inventory

Michigan underlain by well-sorted gravel hills and thick sandy plains, streamflow is typically dominated by groundwater inflow, and these systems comprise the state's well known coldwater stream resources, including the Au Sable, Manistee, and Pere Marquette rivers. Moderate groundwater inflow occurs in streams that drain soils of mixed or intermediate textures, and these coolwater streams support a characteristic fauna, as well as species at the edge of their cold or warmwater limits. For example, trout may occur in limited zones of coolwater streams where groundwater inflow locally is high. Coolwater streams include most Upper Peninsula rivers, and the Kalamazoo and St. Joseph rivers. Streams that drain bedrock or fine-textured soil typically have small groundwater inflow. These streams are termed warmwater streams, and, though groundwater inflow is small, they have baseflow habitats that support a productive and characteristic fauna. The Grand, Tittabawassee, Cass, and Flint rivers are warmwater systems.

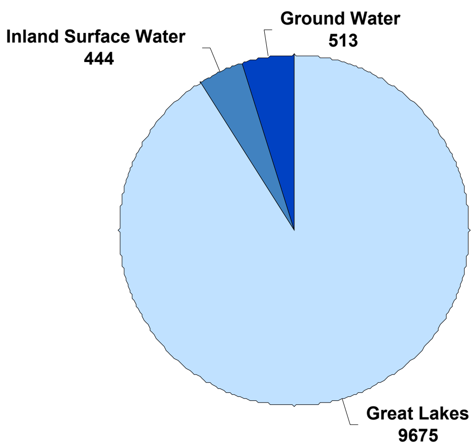
Similarly, groundwater inflow is an important component of the water budget for most Michigan wetlands and inland lakes. In most cases, the wetland or lake surface is simply the water table exposed within a surficial depression or basin. As with streams, the rate of groundwater inflow to these aquatic ecosystems varies and is dependent upon the hydrologic and geomorphic setting of the particular water body. Wetland types are classified according to water source and hydroperiod, and their vegetation reflects these hydrologic characteristics. Fens, and cedar and tamarack swamps have high groundwater inflow, have fairly stable water levels throughout the year, and support plants adapted to wet and nutrient-rich conditions. These wetlands commonly are at the foot of slopes composed of carbonate bedrock or sand and gravel. Other wetlands are characterized by intermediate or low rates of groundwater inflow, and water levels typically drop during dry seasons. Plant and animals found in these wetlands are adapted to characteristic seasonal changes in wet and dry conditions. Michigan's 6500 inland lakes greater than 10 acres in size occur in many hydrologic and geomorphic settings. Thus individual lakes span the same spectrum of groundwater inflow as has been discussed above for streams and wetlands. Groundwater seeps and springs provide unique thermal and chemical habitats along lakeshores, but little is known about their linkages to aquatic life.

Groundwater also discharges into the Great Lakes, and discharge rates vary greatly, again according to hydrologic and geomorphic setting. Groundwater discharge near the lakeshore creates extensive fen wetlands, and, similarly to inland lakes, creates unique microhabitats along the nearshore zone. Groundwater also enters the Great Lakes indirectly as stream baseflow, although in summer it has been warmed by the time it enters the lakes. Little is known about how groundwater discharge influences life in the Great Lakes.

Groundwater Use

Water withdrawals for major water uses are compiled and reported by MDEQ through its Water Use Reporting Program. The goal of the program is to establish a baseline and continuing assessment of major water uses. The program fulfills key requirements of the Great Lakes Charter and Michigan's water-use reporting law (Part 327, Great Lakes Preservation, Natural Resources and Environmental Protection Act, 1994 PA 451, as amended). The program also provides information to a regional database maintained by the Great Lakes Commission and to a national database used for 5-year reporting by the USGS. Information in this section of the report is derived from MDEQ's Water Use Reporting Program reports for 2001, unless otherwise noted.

In 2001, groundwater withdrawals were 513 MGD, about 5 percent of all fresh water withdrawals 9 (figure 11).



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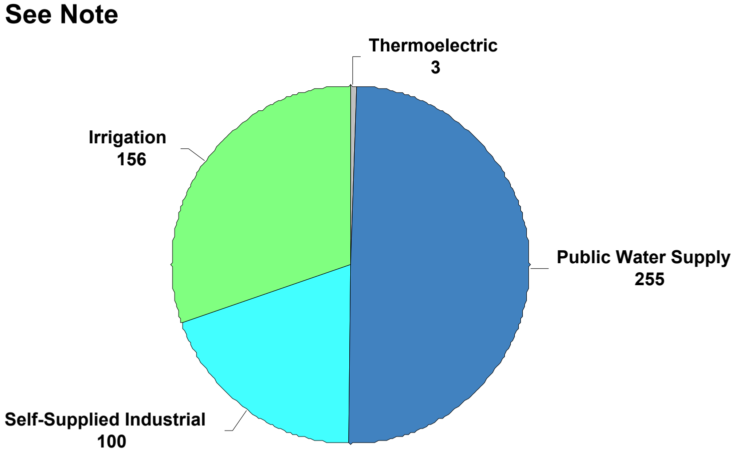

Figure 11. Groundwater (top) is about 5 percent of fresh water withdrawals. Public water supply is the largest groundwater withdrawal, about 50 percent of all groundwater withdrawals (bottom). *Source: MDEQ Water Use Reporting Program 2001*

Note: MDEQ Water Use Reporting Program does not estimate use from domestic (residential) wells. USGS estimates for 2000 are that 2.77 million people in Michigan, averaging 86.3 gallons per person per day, withdrew **239 MGD from domestic wells.**

Although MDEQ does not report groundwater withdrawals by source aquifer, a USGS national water-use summary for 1987 reports that about 28 percent of groundwater withdrawals in Michigan come from bedrock aquifers, with the remaining 72 percent coming from glacial aquifers.

Public water supply is the largest groundwater-use sector, accounting for 255 MGD in 2001, about 50 percent of all groundwater withdrawals. Public water supply is defined as water withdrawn by community public water supply systems that provide year-round service to at least 15 service connections or serve an average of at least 25 residents. Public water supply systems provide water for residential, public, commercial, and industrial uses. It is noteworthy that a 1997 comprehensive survey indicated that 90 percent of the manufacturing facilities in Michigan relied upon public water supply systems for their operations. In 2001, groundwater provided public water supply in every county but Bay and Wayne (figure 12). The highest uses by county were reported for Ingham (37 MGD), followed by Kalamazoo (26 MGD), Oakland (23 MGD), and Calhoun (15 MGD).

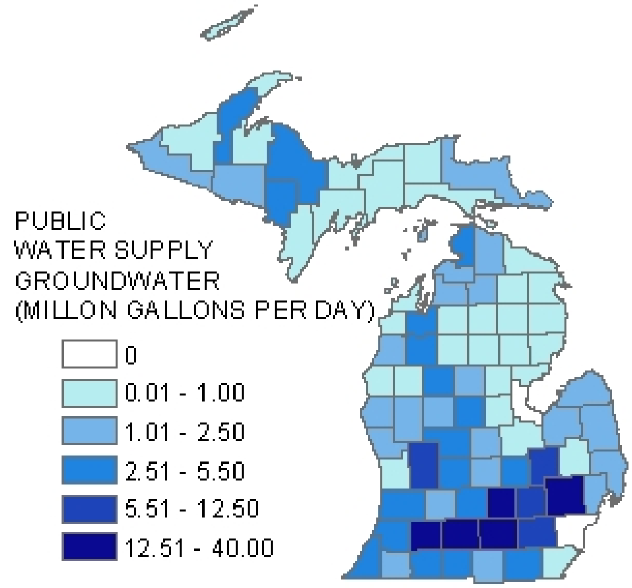

Figure 12. Groundwater is used for public water supply in every county but Bay and Wayne. Highest uses are generally in the southern half of the Lower Peninsula.

Irrigation is the second largest groundwater-use sector, accounting for 156 MGD in 2001, about 30 percent of all groundwater withdrawals. Irrigation is defined as water withdrawn and artificially applied on lands to assist in the growing of crops and pastures or in the maintenance of recreational lands, such as golf courses and parks. About 87 percent of irrigation (135 MGD) is for agriculture; the remaining 13 percent is for golf courses. In 2001, groundwater provided irrigation supply to farms irrigating 14 or more acres in 72 of Michigan's 83 counties (figure 13). The highest uses by county were reported for St. Joseph (27 MGD), followed by Montcalm (25 MGD), Branch (7 MGD), and Kalamazoo (6 MGD). In 2001, groundwater provided for irrigation at golf courses with the capacity to withdraw 100,000 GPD for a

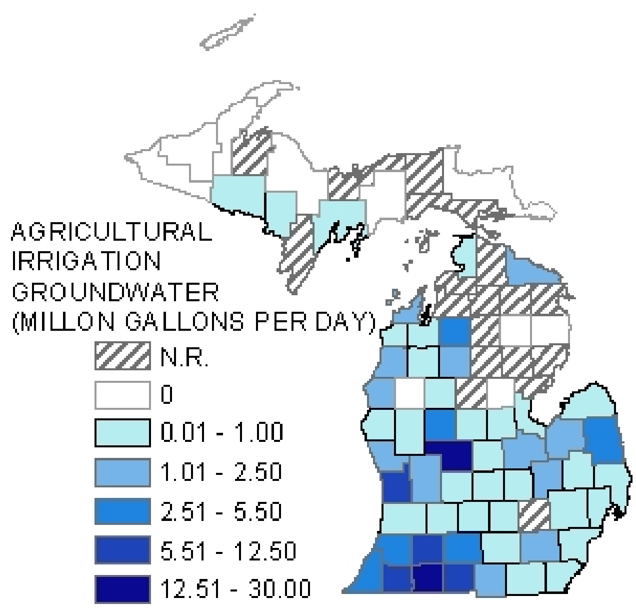

Figure 13. Groundwater is used for agricultural irrigation in most of Michigan. 11 counties reported no farms irrigating 14 or more acres. Data could not be disclosed for another 18 counties to avoid disclosing information for individual farms (hatched area).
Source: MDEQ Water Use Reporting Program 2001

30-day period in 74 of Michigan’s 83 counties. The highest uses by county were reported for Oakland (2.9 MGD), followed by Kalkaska and Kent (1.2 MGD), and Emmet (1.0 MGD).

Self-supplied industrial is the third largest groundwater-use sector, accounting for 100 MGD in 2001, about 20 percent of all groundwater withdrawals. Self-supplied industrial is defined as water withdrawn for use in the manufacture of metals, chemicals, paper, and allied products. Mining water includes water used in the extraction or washing of minerals and liquids. Water supplied to industrial facilities by public water supply systems is not recorded in this sector. In 2001, groundwater provided for self-supplied industries in 56 of Michigan’s 83 counties. The highest uses by county were reported for Kalamazoo (32 MGD), followed by Monroe (14 MGD), Charlevoix (12 MGD), and Calhoun (6 MGD).

Thermoelectric power generation is the fourth largest groundwater-use sector, accounting for 3.3 MGD in 2001, less than 1 percent of all groundwater withdrawals. Thermoelectric power generation is defined as water withdrawn for use by fossil fuel plants (using coal, oil, or natural gas) and nuclear plants. Water supplied to thermoelectric power plants by public water supply systems is not recorded in this sector. In 2001, groundwater provided for thermoelectric power generation in 9 of Michigan’s counties. The highest use by county was reported for Hillsdale (0.89 MGD).

Water-use reporting protocols are established under Michigan law and vary among sectors. Thermoelectric power generation plants, self-supplied industrial facilities, and irrigated golf courses are required to report annually if they have the capacity to withdraw 100,000 GPD during any 30-day period. All community public water supply systems report withdrawals on a monthly and/or annual basis. Estimates are also made for several smaller water-use categories, such as domestic and livestock water use, for reporting in the USGS 5-year national program.

Water-use reporting protocols for agricultural irrigation have varied considerably over the past decade. Prior to 1997, estimates of agricultural irrigation water use were based on rough federal numbers and limited case studies. In 1996, a special provision was enacted in Michigan to develop a method to estimate agricultural irrigation water use. Following development and preliminary verification of an irrigation-demand model, the model was used to estimate water use for agricultural irrigation from 1997 to 2001, using a 1997 federal agricultural census as a baseline. Currently, the model is being used to estimate use from 2002 to 2004, using an updated 2002 federal census. In 2003, Michigan enacted laws to require reporting of agricultural irrigation water use by farms to MDA. The laws provide for MDA to compile the reported water use and provide a summary, totalled for each township, to MDEQ for their water-use reporting program. MDA estimates that in 2004 about 65 percent of farms with a capacity to withdraw 100,000 GPD in any 30-day period reported their use.

Consumptive use is defined in the Great Lakes Charter, and in practice in Michigan, as that fraction of water withdrawn that is not returned to the Great Lakes Basin. Most consumptive use is caused either by evaporation, transpiration, or incorporation into foods and other products. Consumptive use is highly variable between each major water-use sector and within each sector. A generally used estimate in Michigan is that consumptive use constitutes 5 to 10 percent of all withdrawals. In contrast, ideal conformance to generally accepted management practices for agricultural irrigation would result in 100 percent consumptive use. No scientifically based and reported measurements of consumptive use exist, however, for any of the three largest groundwater-use sectors in Michigan.

Although Michigan ranks 8th nationally in population and 3rd in water area, the State ranks much lower in water use. In total water use, Michigan ranks 15th nationally, and it ranks 14th in surface-water use and 25th in groundwater use. On a per capita basis, Michigan ranks 33rd nationally.

EFFECTS OF GROUNDWATER USE

Most effects of groundwater use are clearly known among hydrogeologists. They are, however, somewhat complex, not always intuitive to the lay person, and require more explanation than most other concepts in this report. Broadly speaking, the specific physical laws governing the effects groundwater use are well defined, so that generalizations regarding effects in various areas of the state can be made. These can result in valuable assessment tools. In most cases, however, specific effects in specific places cannot be predicted without site-specific information. Assessment tools can be cost-effective in determining where site-specific information may be needed.

Effects of groundwater development

Under natural (predevelopment) conditions, the groundwater system is in a long-term equilibrium. That is, averaged over a period of time, the amount of water entering (recharging) the system is equal to the amount of water leaving (discharging) the system (figure 14A). Because the system is in equilibrium, the quantity of water stored in the system is constant, varying about some average condition in response to annual or longer-term climatic variations. The possible inflows (recharge) and outflows (discharge) under natural (equilibrium) conditions are listed in Table 1.

Table 1. *Predevelopment Water Budget—Possible sources of water entering or leaving a groundwater system under natural conditions*

Inflow (recharge)	Outflow (discharge)
1. Areal recharge from precipitation that percolates through the unsaturated zone to the water table	1. Discharge to streams, inland lakes, wetlands, springs, and Great Lakes
2. Recharge from losing streams, inland lakes, and wetlands	2. Groundwater evapotranspiration

Humans change the natural flow system by withdrawing groundwater for use, changing recharge patterns by irrigation and urban development, changing the type of vegetation, and other activities. Focusing on the effects of withdrawing groundwater, the source of water for pumpage must be supplied by (1) more water entering the system (increased recharge), (2) less water leaving the system (decreased discharge), (3) removal of water stored in the system (lowered water levels), or some combination of these three (figure 14B).

It is the changes in the system that allow water to be withdrawn. That is, water must come from change of flows or storage. The predevelopment water budget does not provide information on where the water will come from to supply the amount withdrawn. Furthermore, the predevelopment water budget only indirectly provides information on the amount of water perennially available, in that it can only indicate the magnitude of the original discharge that can be decreased (captured) under possible, usually extreme, development alternatives at possibly significant expense to the environment.

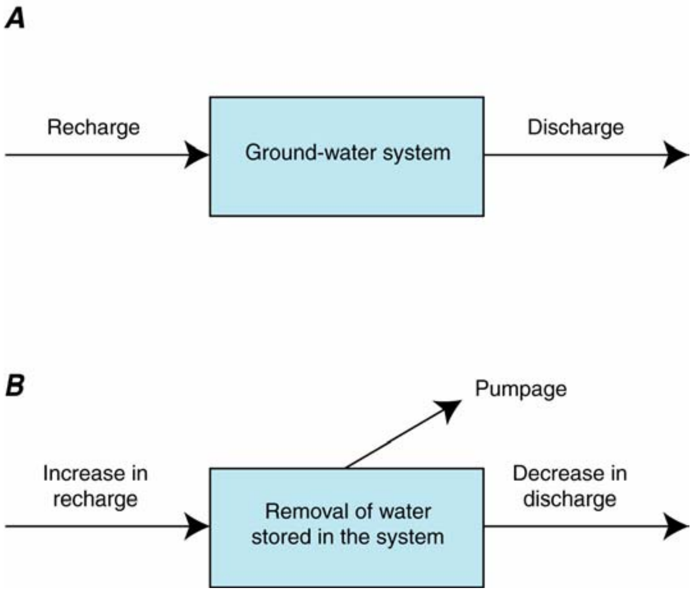

Figure 14. Diagrams illustrating water budgets for a groundwater system for predevelopment and development conditions. (A) Predevelopment water-budget diagram illustrating that inflow equals outflow. (B) Water-budget diagram showing changes in flow for a groundwater system being pumped. The sources of water for the pumpage are changes in recharge, discharge, and the amount of water stored. The initial predevelopment values do not directly enter the budget calculation. *Source: USGS Circular 1186*

Regardless of the amount of water withdrawn, the system will undergo some drawdown in water levels in pumping wells to induce the flow of water to these wells, which means that some water is removed from storage. Sometimes the change in storage is a transient phenomenon that occurs as the system readjusts to the pumping stress. The relative contributions of change in storage, reduced natural discharge, or increased recharge evolve over time. Eventually a new equilibrium may be reached, the change in storage stops, and pumpage is equal to decrease in discharge plus increase in recharge. Increases in recharge as a result of pumping are generally small compared to decreases in natural discharge.

Thus the long-term source of water to discharging wells is typically a change in the amount of water entering or leaving the groundwater flow system. How much water is available for use depends upon how these changes in inflow and outflow affect the surrounding environment and what the public defines as undesirable effects on the environment.

A common misconception is that a predevelopment water budget for a groundwater system can be used to calculate the amount of water available for human use. This concept has been referred to as the “Water-Budget Myth” and is linked to the idea that development is “safe” if the rate of groundwater withdrawal does not exceed the rate of natural recharge. It is a myth because it is an oversimplification of the information needed to understand the effect of developing a groundwater system. As human activities change the system, the components of the water budget (recharge, discharge, and change in storage) also will change and must be accounted for in any management decision. Understanding water budgets and how they change in response to human activities is an important aspect of groundwater hydrology—it is critical information for computer models of groundwater flow. **However, a predevelopment water budget, particularly an estimation of natural recharge, is of limited value in determining the amount of groundwater that can be withdrawn on a sustained basis.**

Effects on Groundwater Flow to and from Surface Water

Development of groundwater or surface water affects the other. In this section, discussion and examples focus on streams. The effects of development on other surface-water bodies, however, are similar to those on streams.

Streams either gain water from the groundwater system or lose water to it. Many streams do both, as the gradient of the stream changes in relation to the gradient of the nearby water table.

Under natural conditions, groundwater makes some contribution to streamflow in all perennial streams in Michigan.

At the start of pumping, 100 percent of the water supplied to a well comes from groundwater storage (figure 15). Over time, the dominant source of water to a well, particularly a well completed in an unconfined aquifer, changes to streams. This water may either be decreased groundwater discharge to the stream or increased recharge to the groundwater system from the stream. In either case, streamflow reduction occurs and is often referred to as streamflow capture. In the long term, the cumulative streamflow capture from a groundwater system can approach the total amount of water being pumped from that system.

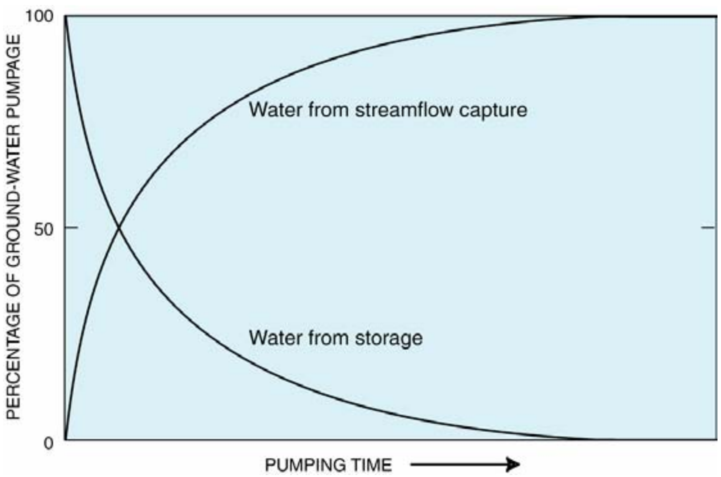

Figure 15. The principal source of water to a well can change with time from groundwater storage to capture of streamflow. The percentage of groundwater pumpage derived from groundwater storage and capture of streamflow (decrease in groundwater discharge to the stream or increase in groundwater recharge from the stream) is shown as a function of time. The time scale of the curves shown depends on the hydraulic characteristics of the aquifer and the distance of the well from the stream. *Source: USGS Circular 1186*

The adjustment of the groundwater system to the new stress of a well may take place over days, years, or decades. The amount and rate of change are governed principally by (1) the hydraulic conductivity and storage properties of the groundwater system, (2) the rate and duration of pumping, and (3) the location of the pumping well in relation to the stream. Determining the effects of groundwater pumping on streams is a complex task. Typically this task is accomplished using a computer model of groundwater flow based upon hydrologic and geologic data collected in the area of interest.

Results of pumping can have long-term residual effects on streamflow. A USGS computer model of a stream-aquifer system in Idaho was used to demonstrate this. The model simulated 30 years of pumping followed by 70 years of no pumping. Depletion of flow to the stream increased for about 15 years after pumping stopped. Depletion continued during the entire 70-year nonpumping period. After 70 years of no pumping, streamflow depletion was still 15 percent of the average pumping rate over the 30 years of pumping. Although this illustration may not be directly transferable to a specific groundwater system in Michigan, it does show the complexity involved in attempting to understand the effects of groundwater development on surface-water resources.

Effects on Storage

Previous discussions of the groundwater flow system have focused on its role as a water distribution system—moving water from recharge areas to discharge areas and wells. The huge volumes of water stored in groundwater flow systems also warrant focusing on the systems as groundwater reservoirs.

Water levels in aquifers are constantly moving up or down in response to natural and human-induced stresses, such as recharge or pumping (figure 16). Consequently, the term “static water

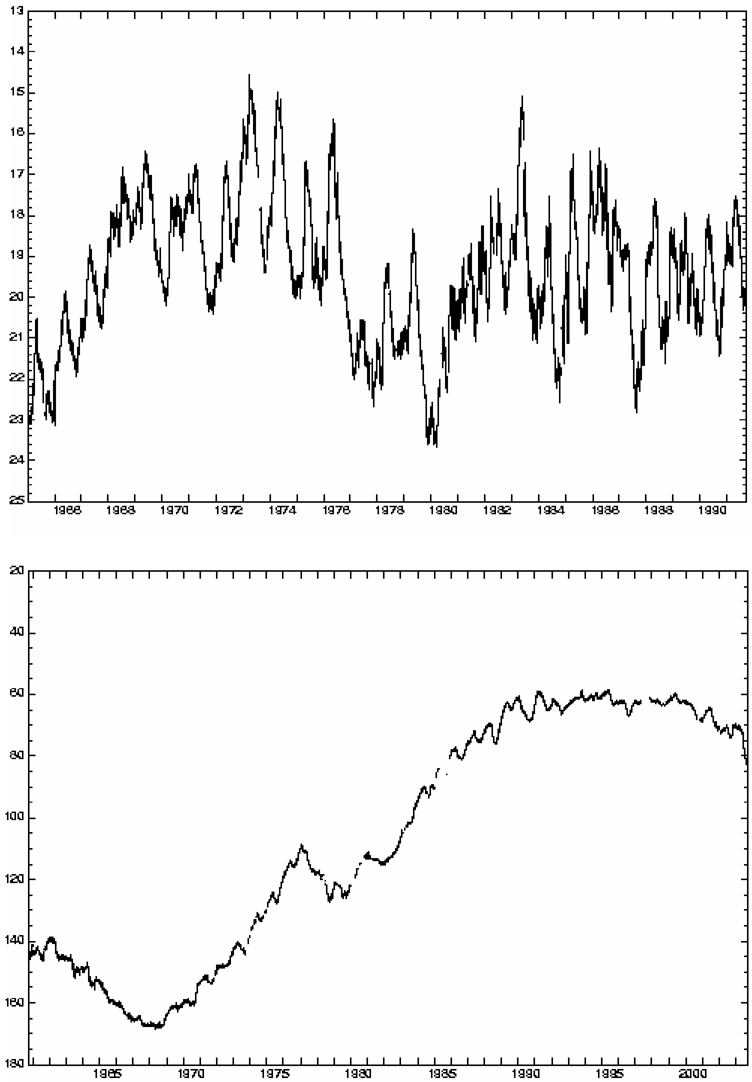

Figure 16. Groundwater levels are constantly moving in response to either natural or human-induced stresses. The upper hydrograph is for a shallow well near Lansing. The water level in the well is affected mostly by changes in recharge. The lower hydrograph is for a bedrock well in Lansing. The increase in water level beginning in the late 1960s resulted from the city redistributing its pumpage.
Source: USGS National Water Information System

level" should be avoided—groundwater levels are seldom static. Changes in water levels represent a change in the amount of water stored in the aquifer. The change in the amount of water stored for a given change in water level depends upon the porosity of the aquifer. For instance, if 1 foot of water recharges an aquifer, and the porosity of the aquifer is 10 percent, then the water level in the aquifer will increase 10 feet. Similarly, if the porosity is 20 percent, and 1 foot of water recharges the aquifer, then the water level will increase 5 feet.

Changes in water levels in aquifers are measured in monitoring wells. For these measurements to be meaningful, several factors need to be considered. First, the depth of the well must be known, as well as the length of the opening of the well. Second, the hydrogeology of the area must be known so that the water level can be related to a specific aquifer and a specific vertical location within that aquifer. Third, the presence or absence of nearby pumping wells should be known. Some monitoring wells are useful for tracking changes in storage in response to pumping stresses. Others are useful for tracking natural changes in water levels caused by seasonal and longer-term changes in recharge. Generally a number of monitoring wells are needed at various locations in an aquifer system if one is to understand and manage a regional resource.

The amount and rate of change in storage in response to pumping in an aquifer are primarily related to two quantifiable characteristics of the aquifer. The first is transmissivity, which is the hydraulic conductivity of the aquifer multiplied by the thickness of the aquifer. Transmissivity can be thought of as a measurement of the ease with which water can move through an aquifer. The second characteristic is storativity, which can be thought of as a measurement of the amount of water that an aquifer can release or store in response to a change in water level. Transmissivity and storativity can only be measured by conducting a controlled aquifer test, wherein water levels are measured in monitoring wells during and after pumping in a nearby well. Aquifer tests are relatively expensive to conduct because of the costs of drilling wells, purchasing or renting pumping and monitoring equipment, and the cost of labor to conduct a test that may run for 24 hours or more. Moreover, aquifer tests only quantify transmissivity and storativity in the area of the test. These characteristics may vary from place to place within the same aquifer; such variability is common in glacial aquifers. A frequent and cost-effective use of computer models is to estimate transmissivity and storativity in an aquifer system.

Storativity of confined and unconfined aquifers are very different. Therefore the response of confined and unconfined aquifers to pumping is very different (figure 17). Typically, the storativity of a confined aquifer is at least 100 times smaller than the storativity of an unconfined aquifer. Consequently, the rate at which the effects of pumping spread in a confined aquifer is 100 times or more faster than it is in an unconfined aquifer. Often, wells pumping from deep parts of an unconfined aquifer have effects more similar to those in a confined aquifer. Also, if long-term pumping in a confined aquifer lowers water levels below the top of the aquifer, then the aquifer becomes unconfined in its response to pumping. Groundwater conflict areas in Saginaw and Monroe Counties are in confined aquifers. In Monroe County, the Carbonate aquifer has a very low storativity and a high transmissivity, resulting in regional effects of groundwater withdrawals. Parts of this aquifer, formerly confined, are now unconfined due to lowered groundwater levels.

Extended periods of dry weather, droughts, or long-term climatic changes can significantly affect the amount of water stored in an aquifer system. These effects are usually exacerbated by lower flows in streams, lower water levels in lakes and wetlands, and increased pumping for irrigation of turf and crops. Groundwater flow models are useful tools for managers to understand the potential water-level changes that can result from these natural events. The models can be used to determine optimal locations and rates of pumpage that will minimize pumping costs or undesirable effects on surface water.

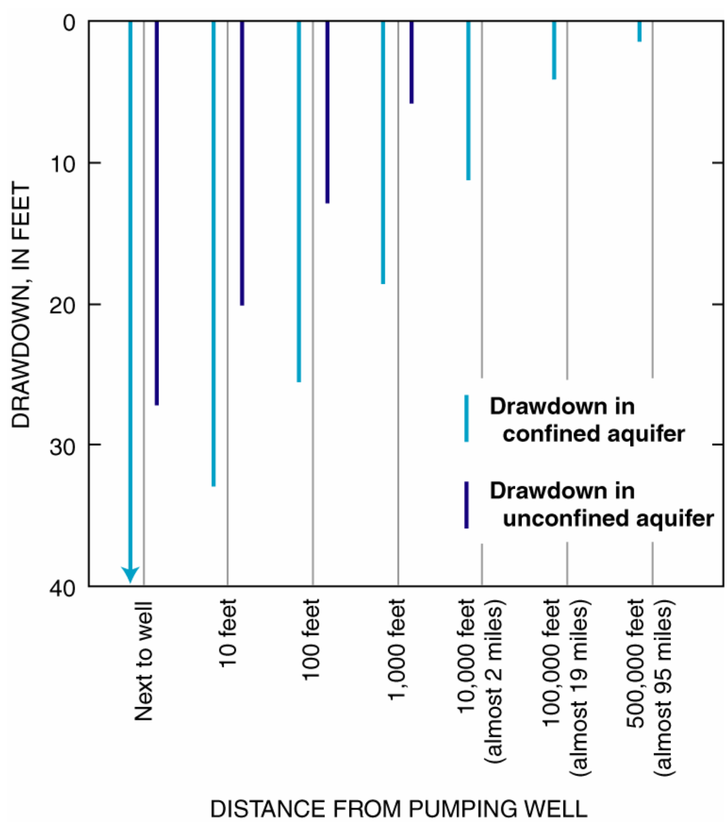

Figure 17. It is critical to know whether or not an aquifer is confined, because confined and unconfined aquifers behave so differently in response to the same pumping rate. As illustrated in this schematic diagram, the amount of drawdown and the distance at which drawdown occurs are much greater in confined aquifers than in unconfined aquifers. Note that the distances on the x-axis are not constant or to scale.
Source: USGS Circular 1186

Relation to Water Quality

Water quality is closely linked to sustainability issues and the effects of groundwater development. There are three principal linkages. The first are effects on aquatic ecosystems caused by reduced discharge of groundwater to streams, lakes, and wetlands. These effects are discussed in the next section. The second is the land-surface/water-table connection. The third is the movement of poor quality water into areas that had good quality water prior to groundwater development.

Human activities at or near the land surface can profoundly affect the quality of groundwater. The movement of potential contaminants to the water table and into the groundwater-flow system can result in water-quality degradation to the point where the water is unsuitable for human uses or where the water contaminates surface water when it discharges from the groundwater flow system. Michigan's Wellhead Protection Program is designed to protect drinking water supplies in aquifers from contamination by (1) determining the land-surface area that contributes recharge to a supply well and (2) developing a Wellhead Protection Plan to manage potential contamination sources in the contributing area and in the zone of travel from this area to the supply well. Determining the contributing area and the zone of travel is complex and requires the use of a groundwater flow model that is based on local hydrologic and geologic information (figure 18). The discharge of contaminated groundwater to surface water, where the contamination results from the widespread application of chemicals on the land surface (nonpoint-source contamination), is probably an important source of surface-water contamination in Michigan, but it is largely unstudied and unaccounted for. The discharge of contaminated groundwater from known point sources of contamination has been closely studied at many places in Michigan as a result of state regulatory programs.

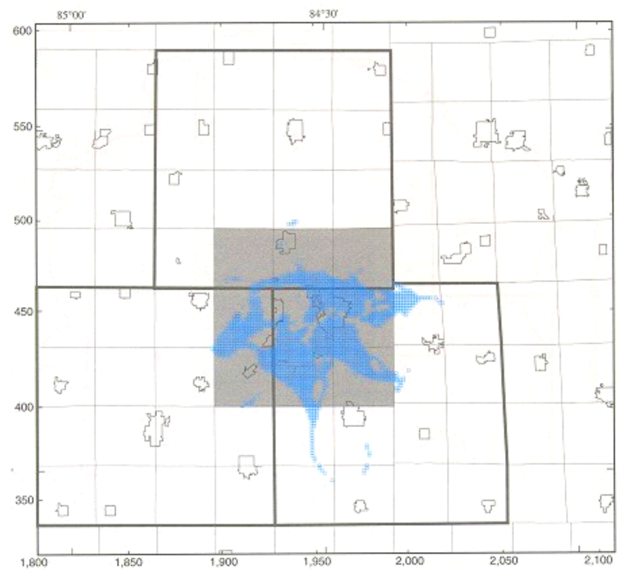

Figure 18. Blue represents areas at the land surface that contribute recharge to public water supply wells in the 9-township Lansing metropolitan area (gray area). The areas contributing recharge to wells were determined using a groundwater flow model. *Source: USGS Water-Supply Paper 2480*

Throughout Michigan, groundwater quality generally is poorer in deep parts of aquifers than in shallow parts. This is a natural result of the residence time of groundwater. Groundwater in deep parts of aquifers may have traveled tens or hundreds of miles and for decades, centuries, or millennia. During this time the groundwater dissolves minerals in the geologic materials through which it moves, resulting in poor quality water after long residence times.

The depth to water containing naturally dissolved chemicals (total dissolved solids) greater than 1000 parts per million has been determined and mapped for most of the Lower Peninsula of Michigan (figure 19). In areas of significant amounts of long-term pumping, such as the Lansing area, water managers must consider the potential for upward movement of brackish or saline water into the producing areas of aquifers. In Monroe County, poor quality water occurs at relatively shallow depths and therefore limits the availability of drinking water, particularly where

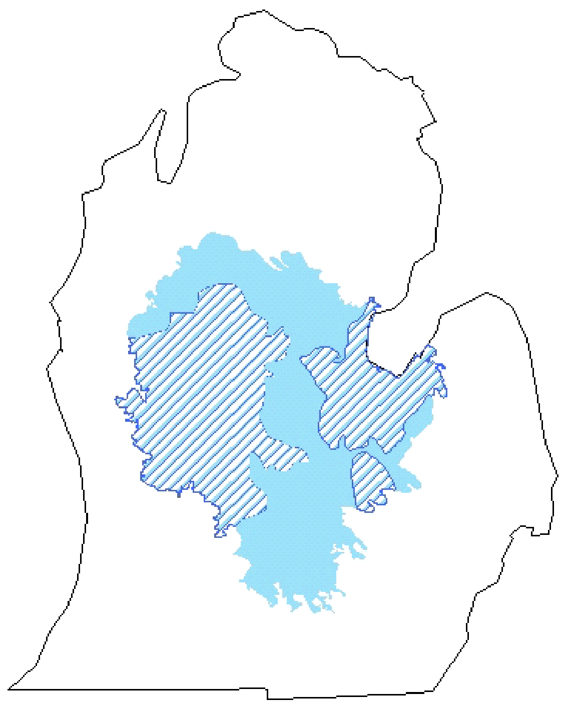

Figure 19. Natural water quality can be a limitation on the availability of groundwater for human uses. This map shows areas of the Saginaw aquifer that contain fresh water at the top (blue) and those that contain saline water. (hatched) In areas with fresh water, large withdrawals have the potential to draw up saline water from below.
Source: USGS Professional Paper 1418

water levels in the aquifer have declined due to regional withdrawals. Natural water quality can limit the availability of drinking water, particularly for self-supplied domestic needs, even if total dissolved solids are not high. The principal naturally occurring chemicals in Michigan that limit water availability are arsenic and radionuclides.

Effects on Aquatic Ecosystems

Understanding the effects of groundwater withdrawals on aquatic ecosystems is difficult, given the previously stated complexities of understanding the effects of groundwater withdrawals on surface water. An added challenge is that little research in Michigan has been devoted to how much groundwater discharge is required by particular biota in various aquatic ecosystems, other than with respect to stream fishes. Although scientists understand where stream fishes occur and what flows they require, they would agree that this basic understanding does not provide for statewide estimation of the specific and complex effects of individual groundwater development situations. Each situation requires a site-specific study of the complex local groundwater/surface-water interactions.

There are a number of considerations that suggest approaches to addressing this challenging and important problem. First, many of the basic physical and biological principles are understood. Second, the extremes are understood. That is, an aquatic ecosystem in a large stream with most of its flow derived from groundwater cannot be adversely impacted by a few high-capacity wells. Conversely, a sufficiently small headwater stream with any amount of groundwater inflow can be adversely impacted by a single high-capacity well. Also, a high-capacity well in a deep, confined bedrock aquifer may have indiscernible impacts on streams, whereas a shallow high-capacity well near a stream in a surficial aquifer may have a discernible impact on the nearby stream. Third, Michigan agency and university scientists have studied relationships among various stream and fish attributes throughout the state, and they have developed predictive tools linking variables such as watershed size, summer water temperature, and fish species abundances. For instance trout occur in smaller watersheds with colder temperatures, while walleye and many sucker species are found in large watersheds with warmer temperatures. All of these above considerations could be used to develop an assessment tool that could be used to define areas of Michigan where individual or cumulative groundwater withdrawals have the potential to adversely impact aquatic ecosystems.

Furthermore, agency and university scientists have developed a semi-quantitative tool that can be used to estimate the amount of groundwater discharge to specific stream reaches. Coupled with estimates of baseflow developed by USGS, scientists could estimate the natural groundwater component of streamflow for stream reaches, statewide. This estimate could be used to predict expected water temperatures for these reaches. Baseflow and water temperature are the key factors relating groundwater inflow to aquatic ecosystems. Furthermore, it is possible to estimate water budgets for stream subwatersheds, statewide. If one assumes (1) that the effect of a particular groundwater withdrawal on groundwater discharge to a stream is instantaneous, and (2) that the affected stream is the nearest stream, then one can predict the potential changes in streamflow, water temperature, and fish abundances related to withdrawals for all stream catchments. Although these assumptions will not be fully met in any real situation (and in some cases they will be incorrect), such modeling could provide for a statewide tool for assessing the potential effects of individual and cumulative withdrawals on aquatic ecosystems. Such an approach may also be useful as an assessment tool for effects of groundwater withdrawals on wetland and inland lake ecosystems.

REGULATORY AND LEGAL BACKGROUND

Michigan has a long history of protection of groundwater. Protection of groundwater in Michigan has five themes: (1) management and protection of drinking water sources; (2) management and protection of aquifers from contamination from discharge; (3) management of existing contamination in groundwater (4) gathering data and monitoring uses; and (5) management of groundwater quantity.

Michigan's history with respect to the first four themes is considerable because of the State's reliance on groundwater for drinking-water supply. This history began with drinking water and waste water laws in 1913, and was greatly strengthened by the state programs resulting from the federal Clean Water Act and Safe Drinking Water Act. More recently, groundwater protection measures have focused on the management of contamination in soil and in groundwater. Michigan's history with respect to the fifth theme is more limited, but does date to 1905. The Flowing Wells Damages Act of 1905 (Act 107) stated, "Any artesian or flowing well, the water of which is unnecessarily allowed to run to waste in an unreasonable manner to the depletion or lowering of the head or reservoir thereof to the detriment or damage of other wells supplied from the same head or reservoir, is a nuisance, and its owner and the owner of the land on which it is situated are subject to all the actions for abatement and damages in favor of the person or persons injured, as provided by law for other nuisances or tortious acts." Thus, this early law established a conservation basis for groundwater use.

Probably because of its abundant water resources, Michigan has a minimal regulatory framework and judicial history with respect to quantities of groundwater withdrawn for use. Nearly all of the drivers for groundwater management and regulation in Michigan relate to water quality, where the principal driver have been the federal Clean Water Act and Safe Drinking Water Act and their implementation in Michigan. As described earlier under water use, Michigan's Water Use Reporting program is driven principally by the Great Lakes Charter and recent groundwater-use conflicts. The 2001 Annex to the Great Lakes Charter may drive additional reporting or regulation. Michigan's statutory conformance with the Annex is described later in this report.

In Michigan, no groundwater withdrawal is subject to permit based upon amount of use. Public water suppliers must receive a permit, but the permit process is designed principally to ensure that the proposed water well can sustain the required pumpage to meet anticipated demand.

Thus this process is a technical hydrogeological and engineering review of aquifer-test data. Registration and reporting of use is required for certain uses and sectors, as discussed under water use in this report. The only regulation directly related to the quantity of groundwater use is the recent groundwater conflict law (2003 PA 177) that provides for a non-judicial process for small-capacity well owners to file a complaint against a high-capacity well owner, if it can be shown that the high-capacity well has interfered with the proper function of the small-capacity well (see Implementation and Results from Groundwater Dispute Resolution Program section of this report). No regulation exists regarding the quantity of groundwater use and potential impacts on surface water or on the biota that depend on that surface water.

In Michigan most legal decisions related to the quantity of groundwater use are for cases involving a new groundwater use interfering with an existing groundwater use. In most of these cases, the new use was a larger use than the existing use. In these cases, the court consistently has ruled that the new use was to some degree unreasonable and that some measure needed to be taken to restore or replace the existing use. The basis of these rulings is the doctrine of reasonable use, which is essentially a judicially created body of decisions that loosely describes the bounds of reasonable use and the balancing of interests among various users.

From the perspective of groundwater quality management, many governmental programs now exist at the State and local levels that either legislate behavior (directly regulate) or motivate behavior (promote though incentives or support) to protect groundwater quality. Some of Michigan’s successful programs in this area are non-regulatory, such as the Groundwater Education in Michigan Program, Farm*A*Syst and Home*A*Syst, Michigan Turfgrass Environmental Stewardship Program, Abandoned Well Management Program, and the Wellhead Protection Program

Michigan’s Wellhead Protection Program is one of the best in the nation. Although voluntary, it requires detailed, state-approved hydrogeologic studies that are scientifically sound. The state provides financial and water-quality monitoring incentives to participants in this program. The state has also allowed local communities to work together on developing and implementing Wellhead Protection Programs (WHPP) in areas where it clearly makes sense. Each community must still adopt a wellhead protection plan for their local protection areas and set up a wellhead protection committee to oversee and monitor implementation. This is necessary because each community has its own planning and zoning powers which are the basis for its wellhead management strategies and each community's water supply agency must have its own contingency plan. However, some communities have pooled their local and grant resources and staff to carry out certain development and implementation portions of the WHPP, such as regional groundwater modeling for delineation, education, management strategies, abandoned well closures and contaminant source inventories. Cooperating communities can save money and staff resources, and they also create a "regional" message of groundwater protection that impresses upon people the importance of working together beyond political boundaries to protect a common groundwater resource. Currently, there are 295 communities in Michigan actively involved in a Wellhead Protection Program. The state should not merely allow—but should actively encourage—regional and multi-jurisdictional approaches to groundwater management and wellhead protection.

SUSTAINABILITY OF STATE'S GROUNDWATER USE

Definition of Sustainability of Groundwater Use

Definitions of sustainability vary depending on the user. For example, an ecologist may view sustainability in terms of carrying capacity—the population of a given species must live within the resources available from the environment if it is to remain viable over the long-term. Alternatively, an economist may view sustainability in terms of the “don’t spend principle”—sustainability requires that consumption not result in the liquidation or decline of capital.

The emerging field of sustainable development has developed from the multitude of concepts and definitions surrounding sustainability. Perhaps the most widely used definition of sustainable development is that set forth by the Brundtland Commission—***sustainable development is development that meets the needs of the current generation without compromising the opportunities of future generations to meet their needs***.

A critical step in providing guidance on how Michigan will address water resources issues into the 21st century is relating the concepts of sustainable development to water resources, and to groundwater specifically. A valuable resource in this endeavor is the Sustainable Water Resources Roundtable (SWRR), which is part of the Advisory Committee on Water Information and was established by the federal government to enable water-information users and professionals to advise the federal government on the effectiveness of its water-information programs. The SWRR mission is to promote the exchange of information regarding water resources sustainability among representatives of government and industry, and to include the interests of environmental, professional, public interest, and academic groups. The SWRR views sustainable development of water resources as a multi-dimensional way of thinking about the interdependencies among natural, social, and economic systems in the use of water, and it notes that efforts to achieve economic vitality should occur in the context of the enhancement and preservation of ecological integrity, social well-being, and security. The sustainable use of water involves the following:

- policies, plans, and activities that improve equality of access to water;
- recognition that there are limits and boundaries of water use beyond which ecosystem behavior might change in unanticipated ways;
- consideration of interactions occurring across different geographical ranges: global, national, regional, and local; and
- a view of the future that attempts to assess and understand the implications of the decisions made today on the lives and livelihoods of future generations, as well as the natural ecosystems upon which they depend.

Principles of Sustainability Relating to Groundwater

The sustainable use of groundwater resources requires an understanding of hydrologic principles. In particular, it is critical that the following elements be appreciated: (1) consideration of the total hydrologic system; (2) maintaining a long-term perspective toward management of water resources; and (3) acknowledging the role of spatial scales. Each of these elements is described in more detail below.

Consideration of the total hydrologic system—understanding that the hydrologic system is complex and interconnected between groundwater and surface water and that it is not merely a grouping of isolated compartments—is critical if we hope to understand potential problems related to groundwater development. This connectivity has important consequences for sustainability. For example, as discussed earlier, the dominant source of water to wells, especially those in unconfined aquifers, usually changes over time from groundwater storage to surface-water capture. As a consequence, groundwater withdrawals may result in the quantity of water in streams, lakes, wetlands, and springs being lowered. In addition, water quality may be affected; if the stream is contaminated, then those contaminants potentially can enter the groundwater system.

Maintaining a long-term perspective is important not only because slow hydrologic cycles mean that impacts can take years or decades to manifest themselves, but also because climatic conditions can take many years to have a demonstrable influence on water resources. Given the coupled long-term effects of groundwater development and climate variability on the hydrologic cycle, combined with the complexity of the interconnection of groundwater and surface water, the cumulative effects of development may produce substantial and unintended effects on surface-water resources. Although it is recognized that groundwater development decisions made today will affect surface water, in most cases those effects may not be fully apparent for many years.

Acknowledging the role of spatial scales suggests that spatially explicit analysis of sustainability is critical. Even in regions with apparently abundant water supplies, local areas may have insufficient water for all desired uses and for the environment. The Great Lakes region is an excellent example. Here we have a large percentage of the world's fresh water, yet sufficient water supply for human uses has become an issue for Milwaukee suburbs and owners of domestic wells in parts of Michigan.

Use of Indicators to Evaluate Groundwater Sustainability

Criteria and indicators are useful tools in evaluating sustainability. Criteria are defined as standards or points of reference that help in choosing indicators; indicators are measurements that track processes and conditions over time. Indicators should be measurable, based on readily available or obtainable information, consistent, and comparable among various geographic regions. Table 2 provides an example of how criteria and indicators can be applied.

Table 2. *Hypothetical examples of criteria and indicators for the goal of providing water for the environment*

Different types of criteria	Associated indicator
As a target	10% increase in water for environment
As a direction of change	Increase water for environment
As a category for potential directional goal or target	Adequate water supply and timing for environment

The development of indicators to track the status and trends of environmental resources is an emerging issue. Recent efforts by the Heinz Center and USEPA have focused on national indicators. However, there is a growing recognition that, to be effective, indicators must be developed at local and regional scales.

Development of indicators is challenging. Any list of indicators should be refined over time, as needed. The development of indicators should support an informed debate about groundwater use and its relationship to sustainability. Indicators should consider all aspects of resources, to provide a balanced outlook, and the number of indicators should be short and understandable to all interested parties. Where possible, indicators should be based on known scientific data or understanding. Currently, Michigan has adopted, through 2003 PA 177, an indicator that is in conflict with known science. Specifically, 2003 PA 177, Sec. 31703(2) links conflicts and sustainability to the amount of recharge to an aquifer, stating "...that continued groundwater withdrawals from a high-capacity well *will exceed the recharge capability of the groundwater resource* of the area...." In fact, sustainability and the potential for conflict are not related to the amount of recharge, as noted in previous discussions of the "Water-Budget Myth". Past conflicts in Michigan have not been in areas where groundwater withdrawals exceed recharge. The same will likely hold true for future conflicts.

To show how indictors would be applicable to sustainable development of Michigan's groundwater supplies, table 3 presents example indicators for ecological, social, and economic systems. These are examples only. They are not recommendations of indicators that Michigan should adopt.

Table 3. *Example indicators of sustainable groundwater development for Michigan*

Ecological System	**Streamflow**—mid-summer discharge and timing of flows at key stream gages **Groundwater level**—late-summer water levels at key monitoring wells **Water quality**—number of known contaminated sites discharging groundwater to surface water
Social System	**Public health**—number of domestic wells with nitrate exceeding drinking water maximum contaminant level (MCL) **Education**—number of elementary school systems including water resources or conservation in curricula **Conservation**—number of local governments implementing water conservation or management plans
Economic System	**Sales**—economic value of sales from irrigated agriculture and/or irrigated golf courses **Conservation investments**—economic value of investments to reduce water use by use sector **Demand forecasting**—number of public-supply systems doing demand forecasting **Lost investments**—number and economic value of supply wells abandoned because of contaminated groundwater

Each of the example indicators provides some information regarding sustainability of groundwater development. Taken together, such a set of indicators would provide for a more holistic assessment of sustainability. Consistent measurement of such indicators over time would provide critical information regarding Michigan's trends toward or away from sustainable development. Note that no criteria were applied to these hypothetical indicators. Depending on the values that society places on these indicators, it is possible to add numeric targets (for instance, some percent change), a direction of change (increase or decrease over time), or potential directional target (for instance, adequate groundwater for a particular use sector) as criteria.

Status of Michigan's Groundwater Resources and Relation to Sustainability

The status of Michigan's groundwater resources, the amount of groundwater development, and the effects of development are discussed generally in previous sections of this report. Additional information on these topics is included in the groundwater mapping and inventory completed in August 2005, in response to 2003 PA 148. Still, there is information needed regarding groundwater-resource status that is relevant to the question of the sustainability of Michigan's groundwater use and that is not available. For instance, the total decrease in groundwater stored in aquifers due to withdrawals has not been calculated, nor have trends in storage. Likewise, the decrease in streamflow resulting from large, long-term withdrawals of groundwater has not been calculated, nor have related trends.

Given the above, it is possible to only partially and generally answer the question "Is Michigan's groundwater use sustainable?" In some areas of Michigan, small groundwater uses and abundant available groundwater indicate that these uses are sustainable. In other areas of Michigan, high groundwater uses with growing demand and potential effects on summer streamflow suggest that these uses may not be sustainable. Development of a set of indicators, together with a program to determine their current status and to measure and track future changes, is necessary to determine whether or not Michigan's groundwater use is sustainable.

MICHIGAN'S STATUTORY CONFORMANCE WITH ANNEX 2001

For the last twenty years, the Great Lakes Governors and Premiers have followed a set of principles included in the Great Lakes Charter to guide them in developing, maintaining, and strengthening the regional management regime for the waters of the Great Lakes Basin. Responding to potential threats of diversions outside the Great Lakes Basin, in 1985 the Great Lakes Governors and Premiers signed the Great Lakes Charter to affirm their commitment to:

- protect and conserve the levels of and flows to the Great Lakes,
- protect and conserve the environmental balance of the Great Lakes ecosystem,
- provide for cooperative programs and management of the water resources of the Great Lakes Basin, and
- protect present developments and provide a secure foundation for future investment and development within the region.

In 1986 Congress enacted Section 1109(d) of the Water Resources Development Act (WRDA) (42 U.S.C.§1962D-20) stating that: "No water shall be diverted or exported from any portion of the Great Lakes within the United States, or from any tributary within the United States of any of the Great Lakes, for use outside the Great Lakes Basin unless such diversion is approved by the Governor of each of the Great Lakes States." In 2000 Congress amended WRDA, declaring its "purpose and policy…to encourage the Great Lakes States, in consultation with the Provinces of Ontario and Quebec, to develop and implement a mechanism that provides a common conservation standard embodying the principles of water conservation and resource improvement for making decisions concerning the withdrawal and use of water from the Great Lakes Basin."

In 2001, in response to growing concerns of potential water diversions, other water use concerns, and Congress' 2000 directive, the Great Lakes Governors and Premiers agreed to Annex 2001, reaffirming their commitment to the principles set forth in the Great Lakes Charter. In Annex 2001, the Governors and Premiers committed to develop and implement a new common, resource-based, conservation standard and to apply it to new water withdrawal proposals from the Waters of the Great Lakes Basin.

Annex Implementing Agreements

On December 13, 2005, the Great Lakes Governors and Premiers signed the Annex 2001 Implementing Agreements that will provide unprecedented protections for the Great Lakes-St. Lawrence River Basin. The historic agreements, which include a ban on new diversions of water outside the Basin with limited exceptions, were approved by the Governors of Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania and Wisconsin and the Premiers of Ontario and Québec.

The agreements detail how the States and Provinces will manage and protect the Great Lakes-St. Lawrence River Basin and provide a framework for each State and Province to enact laws protecting the Basin. The Implementing Agreements consist of two elements:

1. The Great Lakes Basin Sustainable Water Resources Agreement (the Agreement), a good-faith agreement among the 8 Great Lakes States, Ontario and Québec; and
2. The Great Lakes Basin Water Resources Compact (the Compact), an agreement among the 8 Great Lakes States.

Once enacted, the Compact will be the enabling legislation in the Great Lakes States.

Included in the Compact are:

1. **Prohibition of New or Increased Diversions:** All new or increased diversions are prohibited, with limited exceptions of straddling communities, intra-basin transfers and consideration of proposals from communities in straddling counties.
2. **Exceptions to the Prohibition of Diversions:** The following are exceptions to the prohibition on diversions:
   - **Straddling Communities—**proposals to transfer water for public water supply purposes to an area within a straddling community but outside the Basin. Proposals within straddling communities that could result in a consumptive use of 5 MGD or greater must meet the Exception Standard and undergo Regional Review (non-binding declaration of finding as to whether the proposal meets the Exception Standard).
   - **Straddling Counties—**proposals to transfer water for public water supply purposes to a community within a straddling county. Proposals must meet the Exception Standard, maximize return of water to the Basin, assure there is no reasonable water supply alternative (including conservation of existing water supplies) undergo Regional Review, and be approved unanimously by those voting on the Compact Council (Great Lakes Governors).
   - **Intra-Basin Transfers—**Proposals between 100,000 gallons per day and 5 MGD of consumptive use must meet the Exception Standard, be regulated by the originating State, return water to the Great Lakes watershed, and ensure that there is no feasible, cost effective, and environmentally sound water-supply alternative, including conservation of existing water supplies. Proposals resulting in a new or increased consumptive use over 5 MGD must meet the Exception Standard, undergo Regional Review, and be approved unanimously by those voting on the Compact Council.
3. **Exception Standard:** Proposals that are excepted from the prohibition on diversions may be approved if:

•The need for all or part of the proposed Exception cannot be reasonably avoided through efficient use and conservation of existing water supplies;
•The Exception is limited to quantities that are considered reasonable for the proposed use;
•The water withdrawn is returned to the source watershed less an allowance for consumptive use.
•The Exception will result in no significant individual or cumulative adverse impacts to the quantity or quality of the waters and water dependent natural resources of the Great Lakes Basin.
•The Exception will incorporate environmentally sound and economically feasible water conservation measures.
•The Exception will be in compliance with all applicable municipal, State, and federal laws and with regional interstate and international agreements.

4. **Management of Withdrawals and Consumptive Uses:** Within five years of the effective date of the Compact (enabling legislation passed in all Great Lakes States and ratification by Congress), each State will create a program for the management and regulation of new or increased withdrawals that will ensure an effective and efficient water management program. This program will ensure that uses overall are reasonable and will not result in significant impacts to the waters and water dependent resources of the Basin. Any State failing to create a program within 10 years of the effective date of the Agreement will apply a threshold level for management and regulation for all new or increased withdrawals averaging 100,000 gallons per day.

5. **Decision-Making Standard for In-basin Use:** In-basin water withdrawals must:
•Return water to the source watershed less an allowance for consumptive use.
•Ensure no significant individual or cumulative adverse impacts to the quantity or quality of the waters and water dependent natural resources.
•Incorporate environmentally sound and economically feasible water conservation measures.
•Ensure compliance with all applicable municipal, State, and federal laws, as well as regional interstate and international agreements.
•Be reasonable based on considerations of: efficient use and avoidance of waste; balance between economic development, social development and environmental protection; supply potential of the water source; degree and duration of any adverse impacts and avoidance or mitigation of impacts; and potential inclusion of restoration of hydrologic conditions and functions.

6. **Water Conservation and Efficiency Programs:** The Compact Council and each State will develop a water conservation and efficiency program:
•The Compact Council will identify basin-wide water conservation and efficiency objectives.
•Within two years of the effective date of the Compact, each State will develop its own water conservation and efficiency goals and objectives and will develop and implement either voluntary or mandatory water conservation and efficiency programs.
•Every five years the States, in cooperation with the Provinces, will review the basin-wide objectives.

- Beginning two years after the effective date of the Compact, the States will promote environmentally sound and economically feasible water conservation measures.

Following are several important issues included within the Compact:

- **Baseline:** To establish a baseline for determining a new or increased diversion, consumptive use or withdrawal, within one year, each State will develop a list of existing withdrawal approvals and/or a list of the capacity of existing systems. The capacity of the existing systems will be based on the most limiting of the withdrawal capacity, treatment capacity, distribution capacity, or other capacity limiting factors.
- **Bulk Water Transfer:** A proposal to withdraw water and to remove it from the Basin in any container greater than 5.7 gallons will be treated as a diversion. Each State will have the discretion, within its jurisdiction, to determine the treatment of proposals to withdraw water and to remove it from the Basin in any container of 5.7 gallons or less.
- **Exemptions:** Withdrawals related to the operation of vehicles or for non-commercial projects on a short-term basis for firefighting, humanitarian, or emergency response purposes are exempt from the prohibition on diversions.
- **Assessment of Cumulative Impacts:** The States and Provinces will conduct a periodic assessment of the cumulative impacts of withdrawals, diversions and consumptive uses every 5 years or each time the incremental Basin water losses reach 50 MGD.
- **Water Resources Inventory, Registration and Reporting:** Within five years each State will develop and maintain a water resources inventory of all withdrawals greater than 100,000 gallons per day over any 30-day period.

Important Definitions

The following definitions are direct quotes from the Annex and Annex Implementing Agreements.

Consumptive Use means that portion of the Water Withdrawn or withheld from the Basin that is lost or otherwise not returned to the Basin due to evaporation, incorporation into Products, or other processes.

Diversion means a transfer of Water from the Basin into another watershed, or from the watershed of one of the Great Lakes into that of another by any means of transfer, including but not limited to a pipeline, canal, tunnel, aqueduct, channel, modification of the direction of a water course, a tanker ship, tanker truck or rail tanker but does not apply to Water that is used in the Basin or a Great Lake watershed to manufacture or produce a Product that is then transferred out of the Basin or watershed. **Divert** has a corresponding meaning.

Environmentally Sound and Economically Feasible Water Conservation Measures mean those measures, methods, technologies or practices for efficient water use and for reduction of water loss and waste or for reducing a Withdrawal, Consumptive Use or Diversion that i) are environmentally sound, ii) reflect best practices applicable to the water use sector, iii) are technically feasible and available, iv) are economically feasible and cost effective based on an analysis that considers direct and avoided economic and environmental costs and v) consider the particular facilities and processes involved, taking into account the environmental impact, age of equipment and facilities involved, the processes employed, energy impacts and other appropriate factors.

Product means something produced in the Basin by human or mechanical effort or through agricultural processes and used in manufacturing, commercial or other processes or intended for intermediate or end use consumers. (i) Water used as part of the packaging of a Product shall be considered to be part of the Product. (ii) Other than Water used as part of the packaging of a Product, Water that is used primarily to transport materials in or out of the Basin is not a Product or part of a Product. (iii) Except as provided in (i) above, Water which is transferred as part of a public or private supply is not a Product or part of a Product. (iv) Water in its natural state such as in lakes, rivers, reservoirs, aquifers, or water basins is not a Product.

Michigan's Statutory Conformance with the Revised Draft Implementing Agreements

The Groundwater Conservation Advisory Council, with assistance of MDEQ staff, has evaluated the requirements in the final Annex Agreements dated December 13, 2005 and provides the following general evaluation of Michigan's current (January 6, 2006) statutory conformance with the requirements identified in the Agreements (table 4). For purposes of this evaluation, the Great Lakes Basin Water Resources Compact was evaluated because it is the binding agreement between the Great Lakes States. Note that Michigan could conform to the intent of the Annex in practice, without necessarily have existing statutes that mandate such conformance. For instance, Michigan currently uses less water per capita than 32 states; we use about 10 percent of the amount per capita of some western states. Thus the need for further conservation and efficiency efforts in Michigan should be evaluated based on the current practices being employed.

Table 4. *Conformance of Michigan's existing statutes with Annex 2001 Implementing Agreements*

Compact Provisions	General Conformance	Does Not Conform	Comments
Compact		X	Michigan would require enabling legislation to implement the Great Lakes Basin Water Resources Compact.
Definitions		X	Michigan statutes do not currently include numerous definitions in the Compact such as Consumptive Use, Diversion, Environmentally Sound and Economically Feasible Water Conservation Measures, Intra-Basin Transfer, Product, Public Water Supply Purposes, Regional Review, Return Flow, and Source Watershed.
Water Resources Inventory, Registration and Reporting	X*		*Michigan does not require well-specific agricultural reporting.
Water Conservation and Efficiency Programs		X	Michigan would be required to develop water conservation and efficiency goals and objectives and, develop and implement a water conservation and efficiency program.
Regional Review of Proposals		X	Michigan does not have binding legislative authority to subject to Regional Review proposals for new or increased consumptive use of 5 million gallons per day or greater. However, the State has exercised its duties under the Great Lakes Charter for notification and consultation with the other States and Provinces for diversions of water over 5 million gallons per day.

Table 4—continued. *Conformance of Michigan's existing statutes with Annex 2001 Implementing Agreements*

Compact Provisions	General Conformance	Does Not Conform	Comments
Prohibition of New or Increased Diversions		**X**	Michigan would need to revisit legislation prohibiting diversions out of the Great Lakes Basin within the State.
Management of Intra-Basin Transfers		**X**	Michigan does not have authority to regulate intra-basin transfers within Michigan.
Management and Regulation of Withdrawals		**X**	Michigan does not have the authority to manage and regulate new or increased withdrawals.
Use of the Decision-Making Standard		**X**	Michigan does not have the authority to subject new or increased withdrawals to a decision-making standard (efficient use and conservation of existing water supplies, limited to quantities that are considered reasonable, return flow; no significant individual or cumulative adverse impacts, incorporate Environmentally Sound and Economically Feasible Water Conservation Measures).
Public Participation	**X**		Michigan public participation process is in conformance with the Compact.
Enforcement	**X**		Current Michigan administrative procedures and laws are in general conformance with the Compact. This area may require additional review.

Pending Legislation in the Michigan Senate and House

The Council recognizes that current legislation before the Senate and the House in Michigan (at the end of 2005 and into 2006) would address many of the Council's Guiding Principles and move the State considerably closer to conformance with the Annex. Given that this legislation is still under consideration, and thus, subject to change, despite wide-ranging public support, the Council is not providing a detailed analysis of this legislation relative to Annex conformance.

The general evaluation of Michigan's statutory conformance with the Annex in the previous section only considers State of Michigan law current as of January 6, 2006. The Council does believe, however, that passage of the pending legislation in its current form, or very close to its current form, will be another major step in the direction of providing a legal framework that will result in the State's statutory conformance with the Annex. Furthermore, the Council believes that the process which Michigan has used during the past few years—relative to the work of the Council and to extensive work sessions associated with the crafting of the current legislative package related to water withdrawal management—is exactly the type of "considered process" envisioned in the Annex.

Although the Council has not discussed a position on the current legislation with the goal of reaching a consensus, many Council members have provided public comment on the legislation. The Council does maintain that Michigan must continue to work diligently towards developing sound policy that maintains a strong fidelity to the principles set forth in the Great Lakes Charter, specifically:

- protect and conserve the levels of and flows to the Great Lakes,
- protect and conserve the environmental balance of the Great Lakes ecosystem,
- provide for cooperative programs and management of the water resources of the Great Lakes Basin, and
- protect present developments and provide a secure foundation for future investment and development within the region.

IMPLEMENTATION AND RESULTS FROM GROUNDWATER DISPUTE RESOLUTION PROGRAM

On June 20, 2005, the Council transmitted a document to the Michigan Legislature describing its findings regarding implementation and results from the groundwater dispute resolution program, as described in 2003 PA 177 (included as Appendix B). Since June 2005, the Council has revisited the contents of the document and is still in agreement with them. The Council, however, does have additional findings included in this section regarding the groundwater dispute resolution program.

The primary additional finding, as noted earlier in this report, is that 2003 PA 177 contains language that is not consistent with scientific understanding of water budgets and the source of water to wells. Specifically, 2003 PA 177, Sec. 31703(2) links conflicts and sustainability to the amount of recharge to an aquifer, stating "...that continued groundwater withdrawals from a high-capacity well will exceed the recharge capability of the groundwater resource of the area....". Because past conflicts have occurred in cases where groundwater withdrawals have not exceeded recharge, the Council does not believe that the quoted language should remain in 2003 PA 177. The situation of conflicts arising from withdrawals exceeding recharge is unlikely to occur in the future.

Another finding relates to 2003 PA 177, Sec. 31703(1)(d) "That the lowering of the groundwater level exceeds normal seasonal water level fluctuations...." The Council notes that because natural groundwater-level fluctuations are not being recorded in most areas of the state, no one will be able to ascertain whether or not the lowering of a groundwater level exceeds natural conditions.

APPENDIX A—SOURCES OF DATA AND INFORMATION

A great deal of the information in the main body of this report is derived from other publications. The Council considered providing references within the report whenever such information was presented, however, the result would have been a plethora of parenthetical citations that the Council thought would significantly detract from the readability of the report. This appendix references the major sources of data and information that were used in writing this report.

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APPENDIX B—JUNE 20, 2005 REPORT TO MICHIGAN LEGISLATURE

TO: Senator Kenneth R. Sikkema, Senate Majority Leader
Senator Patricia Birkholz, Chairperson, Senate Natural Resources and Environmental Affairs Committee
Representative Craig DeRoche, Speaker of the House
Representative David Palsrok, Chairperson, House Natural Resources, Great Lakes, Land Use, and Environment Committee

FROM: Groundwater Conservation Advisory Council

DATE: June 20, 2005

SUBJECT: Report to the Michigan Legislature

Attached is a report of the Groundwater Conservation Advisory Council's findings and recommendations on the implementation and results from the groundwater dispute resolution program created in Part 317, Aquifer Protection and Dispute Resolution, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended, as required by Section 32803(2)(c) of Public Act 148 of 2003.

The Groundwater Conservation Advisory Council consists of the following members:

Voting Members

Jon Allan, Consumers Energy Company
James Clift, Michigan Environmental Council
Jon Coleman, Tri-County Regional Planning Commission
Kurt L. Heise, Wayne County Department of Environment
Fred Henningsen, Retired, Michigan State University Cooperative Extension
Craig Hoffman, The Rock on Drummond Island
Rod Mersino, Mersino Dewatering, Inc.
Thomas Newhof, Prein & Newhof Consulting
Michael Newman, Michigan Aggregates Association
Alan Steinman, Annis Water Research Institute

Nonvoting Members/State Department Representatives

James K. Cleland, Michigan Department of Environmental Quality
Michael R. Gregg, Michigan Department of Agriculture
Paul Seelbach, Michigan Department of Natural Resources

Attachment

cc: Steven E. Chester, Director, Department of Environmental Quality
Stanley F. Pruss, Deputy Director, Department of Environmental Quality

Report to the Michigan Legislature

GROUNDWATER CONSERVATION ADVISORY COUNCIL

JUNE 20, 2005

Introduction

The Groundwater Conservation Advisory Council (Council) was created by Section 32803 of 2003 PA 148 (Act 148). The Michigan Department of Environmental Quality (MDEQ) is the lead state agency to implement Act 148.

The Council's responsibilities are contained in Section 32803(2) and include:

(a) Study the sustainability of the state's groundwater use and whether the state should provide additional oversight of groundwater withdrawals.

(b) Monitor Annex 2001 implementation efforts and make recommendations on Michigan's statutory conformance with Annex 2001, including whether groundwater withdrawals should be subject to best management practices or certification requirements and whether groundwater withdrawals impact water-dependent natural features.

(c) Study the implementation of and the results from the groundwater dispute resolution program created in part 317.

Purpose of this Report

The Council has completed work on Section 32803(2)(c), and this report will cover the findings and recommendations on this specific portion of their work. The aquifer protection and groundwater dispute resolution program created in Part 317, Aquifer Protection and Dispute Resolution, was enacted into law on August 29, 2003, as 2003 PA 177 (Act 177), which added Part 317 to the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (Act 451). Should other substantive issues arise that materially affect our recommendations, an amended report will be prepared and sent to all applicable parties.

The full report to the Legislature is due on February 8, 2006, and this document will be included in that report.

Agreement

The findings and recommendations contained in this report are based upon full consensus agreement of all Council members.

Groundwater Issues and Program Challenges

The work of the Council consisted of: (1) review Act 177; (2) review of all documents prepared by the MDEQ and the Michigan Department of Agriculture (MDA) to implement the program; (3) review of program summary information furnished by the two state departments; (4) discussion of the program in detail after a presentation to the Council at one of their public meetings; and (5) held two Council subcommittee meetings to review the program and identify issues for full Council deliberations.
The groundwater dispute resolution program is implemented by two state agencies – the MDEQ and MDA. The two agencies have met frequently to define the duties and procedures necessary for successful implementation and entered into a Memorandum of Understanding to assure that disputes involving an agricultural well are investigated and resolved by the MDA. There were no complaints received by either state agency or submitted to the Council concerning the responsiveness of the two agencies in implementing the statute.

From September 29, 2003, until July 1, 2004, citizen complaints were limited under the statute to two geographic areas in the state that are at greatest risk for potential groundwater disputes, as identified by MDEQ Director Steven E. Chester on October 8, 2003, in a letter to Lieutenant Governor John D. Cherry and Speaker of the House Rick Johnson. Director Chester designated:

1. The townships of Fremont, Richland, Lakefield, and Jonesfield in Saginaw County, and
2. Monroe County (all townships).

Beginning July 1, 2004, the program was administered on a statewide basis.

Groundwater disputes between “high capacity wells” and “small quantity wells” are the subject of this legislation. There are many technical and complex issues involved with a groundwater dispute, and the Council recognizes that all issues have not been experienced in the limited time of implementation of Act 177. The Council believes that other issues may arise in future years and that these findings will need periodic review as discussed below.

The number of citizen complaints, alleging a groundwater dispute between small quantity wells and high capacity wells, is highly variable and dependent upon many factors, including climate. The availability of groundwater is dependent upon the water levels in the state’s aquifers under both static and pumping conditions. Water levels, in turn, vary with recharge conditions.

The legal right of a property owner to the use of groundwater is based on the common law doctrine of “reasonable use.” This is the principle that must guide Director Chester in determining whether or not to issue an order declaring a groundwater dispute, if a resolution of a complaint cannot be reached.

Attached to this report are spreadsheets containing a complete summary of all complaints received to date in the program and a description of the resolution of those complaints. To date, the Director of the MDEQ has not issued any orders declaring a groundwater dispute.

Findings and Recommendations

Issue #1 – Is the program successful and operating as the Legislature intended?

Discussion – The Council concludes that the groundwater dispute resolution program is operating successfully for the short duration that it has been in place. However, many provisions in the statute have not been used and evaluated. For example:

1. Since no orders have been issued to date under Section 31703(1) or 31703(2), there have been no appeals under Section 31708; no orders issued for temporary provision of water under Section 31705; no cost recovery by the state under Section 31706(2); and no enforcement initiated under Section 31713.
2. To date, the MDEQ has not used the aquifer protection revolving fund created under Section 31710 because disputes have been resolved, and two major hydrogeologic studies were available, funded in the past cooperatively by the state and the U.S. Geologic Survey, in the two primary areas of dispute experienced to date.
3. The owners of high capacity wells involved in the disputes to date have been very cooperative in working with the state agencies and the citizens. Timely and reasonable compensation has been provided to small quantity well owners. In some instances, the owner of a high capacity well has provided compensation even when the Act 177 requirements did not strictly apply.

Finding – The groundwater dispute resolution program is successful and operating as intended by the Legislature, recognizing that the scope of the program to date is limited and not all existing provisions of the statute have been used.

Issue #2 – Is the program adequately funded?

Discussion – The MDEQ receives $200,000 in general fund support (Fiscal Year 2004 and Fiscal Year 2005) and is authorized to hire two full-time equivalent (FTE) staff. In addition, the aquifer protection revolving fund was capitalized at $500,000 (appropriated at $450,000).

The MDA has no appropriation to implement their portion of the program.

Findings and Recommendations – The program is not adequately funded for MDA work. The program is adequately funded for MDEQ work to date, recognizing that many provisions of the statute have not been used. The Council recommends that the MDA be appropriated funds adequate to meet their program responsibilities based upon their level of effort in the past two years and continuing into the future.

Issue #3 – Definitions

Discussion – Two key definitions in Act 177 are “high capacity wells” and “small quantity wells." The Council notes that a change in terminology would improve the public understanding of the definitions.

Recommendation – The Council recommends that the definition of “small quantity well” contained in Section 31701(q) be changed to “low capacity well” for improved clarity and consistency in terminology used in Act 177.

Issue #4 – Are all high capacity wells covered in Act 177?

Discussion – All high capacity wells are not covered. Coverage includes industrial or processing facilities, irrigation facilities, farms, and public water system wells with the capability of withdrawing 100,000 or more gallons of groundwater in one day.

The Council discussed other types of high capacity wells in a regular meeting open to the public. One such use of high capacity wells deemed important is for “lake augmentation,” the practice of withdrawing groundwater and discharging to a lake or impoundment to supplement the natural flow to the water body and raise the water level.

Finding and Recommendation - The Council finds that lake augmentation wells have the potential to create a groundwater dispute, and recommends that lake augmentation wells should be included in the definition of “high capacity well,” Section 31701(j), and a definition of “Lake augmentation well” should be added to Section 31701.

Issue #5 – Complaint Resolution Requirements

Discussion – In Section 31702(4), the MDA is allowed 14 days following the filing of a complaint that alleges interference from an agricultural well to resolve the complaint. If not resolved within 14 days, the complaint is referred to the MDEQ. The program implementation experience to date suggests that this time may be too short in many cases. The MDA may be making substantial progress that could soon thereafter result in an efficient and effective resolution of the complaint.

There are four parties in a complaint involving an agricultural well: the complainant (owner of the small quantity well), the owner of the high capacity well, the MDA, and the MDEQ.

Findings and Recommendations – The Council finds that the 14 days allowed for the MDA to resolve a dispute should be extended in certain cases. The Council recommends that Section 31702(4) be amended to allow an extension to a specific date if all parties agree that the additional time will likely result in resolution of the complaint. Further, the time extension should be revoked upon written request of any one of the parties.

Issue #6 – Notification of Complaint

Discussion – Act 177 does not require the state to notify the owner of a high capacity well when a complaint is filed alleging a groundwater dispute. It is the current policy of the state agencies to notify the high capacity well owner because that is often critical to the resolution process.

Findings and Recommendations – The Council finds that notice to the high capacity well owner following the filing of a complaint is appropriate and essential to the complaint resolution process. The Council recommends an amendment to Section 31702 to add this requirement. The Council also recommends, through educational materials or other means, a requirement for the state to encourage a small quantity well owner to meet and discuss issues with the high capacity well owner in advance of filing a complaint.

Issue #7 – Illegal Wells

Discussion – State legislation was enacted on February 14, 1967 (now Part 127, Water Supply and Sewer Systems, of the Public Health Code, 1978 PA 368, as amended) creating a state well construction code. Any well constructed after February 14, 1967, not meeting the code requirements is considered an “illegal well.” There are many wells constructed before this date that are still in use yet do not conform to the current standards.

The Council recognizes the extraordinary burden of a high capacity well owner if there are small quantity wells in the area constructed before February 14, 1967. If these wells are shallow in depth (less than the state well code standard), any lowering of the groundwater level is likely to create a dispute. However, the number of these wells is decreasing each year as old wells fail and are replaced or wells are abandoned when a community water system is extended.

Findings and Recommendations – The Council finds that the existing language in Section 31706(1) is satisfactory and recommends no action.

Issue #8 – Disputes Involving Two or More High Capacity Wells Or Two or More Small Quantity Wells

Discussion – The Council recognizes that disputes between owners of high capacity wells or between owners of small quantity wells are not covered in Act 177. There are limited or no data readily available to suggest this is a problem.

Findings and Recommendations – The Council finds that disputes between high capacity well owners and disputes between small quantity well owners are disputes between equals with appropriate redress available through usual and customary adjudicative processes. The Council recommends no action other than suggesting that this information be tracked by the MDEQ staff working in the groundwater dispute resolution program.

Issue #9 – Water Use Reporting and Impact on Groundwater Dispute Resolution

Discussion – Water use reporting is covered by Part 327, Great Lakes Preservation, of Act 451, and was amended by Act 148. The data reported to the state are used extensively in the resolution of groundwater disputes.

The owner of a farm, who makes a withdrawal for an agricultural purpose, including irrigation, has two options:

1. Report to the MDEQ under Section 32707, or
2. Report water use to the MDA by annually submitting a water use conservation plan under Section 32708.

Under the second option (reporting under Section 32708), the well location and water use data are aggregated by township. For purposes of groundwater dispute resolution, the aggregated township data is difficult to use and can result in false conclusions by the state agencies implementing Act 177.

The Council recognizes that data compiled at the township level does not provide the necessary detail to investigate and resolve specific groundwater disputes. The Council also recognizes that the data reported to the MDA are supplied at the farm level, not to the same precision as reporting under Section 32707. The MDA then aggregates data to the township level; thus, even when more specific location-based data are available, it is not reported to the MDEQ.

If a complaint is filed under Act 177 against an owner of a high capacity well used for agriculture, the MDA has the initial responsibility for investigating the complaint. The MDA should commence a well investigation, including but not limited to, determining the precise location(s) of wells that may be involved in the dispute. While the MDA may rely on farm level reported data, the MDA should gather any necessary specific well locations from the parties as well as data on well capacity and water use when this information is missing from reported records. This well-specific data and well location data should be added to the record.

If the MDA cannot successfully resolve the dispute within the statutory deadlines, they should transfer all material and pertinent data, including well specific data and precise locations of the wells in question, to the MDEQ. Upon resolution of any well dispute, if it is found that the high capacity well has adversely affected the small quantity well as alleged in the dispute, the data gathered on the wells in question should be entered into the state Wellogic database with as much specificity as exists.

Findings and Recommendations – The Council finds that water use reporting aggregated by township is inadequate for groundwater dispute resolution. The Council recommends clarification to the process that authorizes the MDA to pass well-specific information to the MDEQ for dispute resolution.

Issue #10 – Complaint Tracking and Reporting

Discussion – The MDEQ keeps records of all complaints filed along with the complaint resolution status. In some cases, a complaint is filed, recorded by the MDEQ, and made available to the public via the MDEQ Web page. If the complainant fails to submit a required well assessment, the complaint stays on the MDEQ records even though the high capacity well owner has no duty to respond to the complaint and no dispute resolution process is initiated.

Findings and Recommendations – The Council finds that the public reporting of complaints should be limited to complaints determined to be administratively complete by the MDEQ. The Council recommends that the MDEQ adopt an internal policy to make public only complaints determined by the MDEQ to be administratively complete, or that Act 177 be amended to limit public reporting of complaints to those determined by the MDEQ to be administratively complete.

Issue #11 – Evaluating the Groundwater Dispute Resolution Program

Discussion – The Council discussed the ongoing need for the groundwater dispute resolution program, especially if the number of complaints changes over time.

Findings and Recommendations – The Council finds that a periodic review of Act 177 to determine the need is advisable and further concludes that Act 177 should be amended to include this provision. The Council suggests that this review be conducted by a representative group of stakeholders in a manner open to public access and input.